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SURGERY

VOL. 39 JUNE, 1956 NO. 6

Original Communications

THE GASTROESOPHAGEAL SPHINCTER MECHANISM: AN EXPERIMENTAL STUDY

JOHN W. BRAASCH, M.D.,* AND F. HENRY ELLIS, JR., M.D., ROCHESTER, MINN.

(From the Sections of Surgery and Surgical Research, Mayo Clinic and Mayo Foundation†)

THE high incidence of esophagitis and its complications following operative procedures which destroy the normal esophagogastric junction have emphasized the importance of a complete understanding of the function of this junction. Several excellent recent reviews have discussed in detail the various possible factors that may be responsible for gastroesophageal continence.[3, 6, 13, 14] The various mechanisms which have been thought to ensure unidirectional flow at this junction include: (1) a sphincter action of the diaphragm, the so-called diaphragmatic pinchcock mechanism; (2) an intrinsic sphincter in the region of the esophagogastric junction; and (3) a valve mechanism situated between the terminal part of the esophagus and cardia effected by the oblique entry of the esophagus into the stomach, or by a valve flap of mucous membrane, or by both.

The present study was undertaken in an attempt to increase our knowledge concerning the relative importance of these various factors. The importance of the diaphragm in preventing esophageal reflux has received considerable emphasis, particularly in regard to the technique of hernial repair.[1] The experiments reported herein were concerned primarily with evaluating the importance of the diaphragm in preventing esophageal reflux. A series of experiments were carried out in which the esophagogastric junction was excised or destroyed. The new esophagogastric junction was then left below the diaphragm in some dogs and above the diaphragm in other dogs. The results in the two groups were then compared.

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*Fellow in Surgery, Mayo Foundation.

†The Mayo Foundation, Rochester, Minn., is a part of the Graduate School of the University of Minnesota.

TECHNIQUE AND RESULTS

A total of 30 adult mongrel dogs underwent operations on the esophagogastric junction (Table I). Three procedures were carried out: (1) the Wendel cardioplasty[16]; (2) the Heller esophagocardiomyotomy[10]; and (3) esophagogastrectomy.

TABLE I. ESOPHAGITIS IN DOGS

OPERATION, TYPE	LOCATION OF ESOPHAGOGASTRIC JUNCTION	DOG	TIME POSTOPERATIVE		ESOPHAGITIS PRESENT AT NECROPSY
			INITIAL ESOPHAGITIS, WEEKS	KILLED AFTER, WEEKS	
Wendel	Abdomen	1	7	11	+
		2	6	25	+
		3	3	23	+
		4	1	25	+
		5	1	26	+
		6	19*	24	0
	Thorax	7	3	22	+
		8	8	26	+
		9	8	26	+
		10	2	26	+
Heller	Abdomen	11	12	22	+
		12	None	13	0
		13	None	25	+
		14	2	24	+
		15	12*	24	0
	Thorax	16	16	31	+
		17	6	32	+
		18	15	27	+
Esophagogastrectomy	Abdomen	19	28*	41	0
		20	None	9	0
		21	None	28	0
		22	20	33	+
		23	33	62	+
		24	30	41	+
	Thorax	25	No esophagoscopy	8	+
		26		20	+
		27		8	+
		28		16	+
		29		12	+
		30		16	+
Abdominal esophagus	Abdomen (esophagogastric junction not disturbed)	31	None	28	0
		32	None	28	0
		33	28	28	±
		34	None	26	0
		35	None	25	0

*These animals had very mild esophagitis observed at esophagoscopy during the postoperative period but normal esophagi at autopsy.

In the Wendel procedure a vertical incision 2 cm. in length was made, extending on either side of the esophagogastric junction. This was closed transversely with an inner layer of running catgut and an outer layer of interrupted silk sutures.

The Heller procedure consisted of a myotomy through the gastric and esophageal muscle, extending vertically for 3 cm. on either side of the esophagogastric junction.

The esophagogastrectomy involved removal of an estimated 70 per cent of the acid-bearing portion of the stomach and a Ramstedt pyloromyotomy. The technical details of this procedure have been described previously.[8]

In some dogs of each group the new esophagogastric junction was placed in the thorax 2 cm. above the diaphragm. In others the new esophagogastric junction was left in the abdomen without disturbance of the diaphragmatic crura.

In another group of five animals the esophagogastric junction was left intact. The diaphragmatic esophageal attachments were severed, leaving the vagus nerves intact, and were then resutured at a level 2 to 3 cm. higher on the esophagus. This procedure established an abdominal esophagus at least 2 to 3 cm. in length which lay below the diaphragm and in the abdomen.

The condition of the animals was followed, except where noted in Table I by esophagoscopy at intervals averaging every five to six weeks for varying periods (eight to sixty-two weeks). Any reddening, ulceration, or bleeding from the esophageal mucosa was noted and recorded. In addition, esophageal reflux was studied in some dogs by means of barium instilled into the stomach by gastric tube. At the end of the period of study, the animals were killed and the esophagogastric junction and attachments were carefully inspected.

Reference to Table I shows that esophagitis of varying degree occurred in some animals of each group after destruction of the esophagogastric junction, whether the new esophagogastric junction lay in the thorax or in the abdomen. No striking differences in the severity of this pathologic change were noted. The animals which underwent the Wendel cardioplasty, with the esophagogastric junction being placed in the thorax, were noted to have somewhat more esophageal ulceration than the animals which underwent a similar procedure with the esophagogastric junction remaining in the abdomen. In the animals which underwent esophagogastrectomy, esophagitis developed somewhat later and to a somewhat lesser extent when the anastomosis was left in the abdomen than when it was placed in the thorax. Quite striking, however, was the difference noted in the animals in which the esophagogastric junction remained intact and in which an abdominal esophagus was created. In only one of these five animals was there a suggestion of esophagitis (Table I).

Studies of esophageal regurgitation carried out with barium in some animals confirmed these findings. Wherever the esophagogastric junction was removed or destroyed, regurgitation of barium from the stomach to the esophagus could be produced by abdominal pressure, whether the esophagogastric junction lay above or below the diaphragm.

COMMENT

The results of these experiments indicate quite clearly that whenever the esophagogastric junction is destroyed, esophageal reflux occurs, as evidenced by the development of esophagitis, whether the new esophagogastric junction of the dog lies in the thorax or in the abdomen. This supports the concept that the diaphragm, as such, is not the principal sphincter mechanism that prevents esophageal reflux. In further support of this are the experiments wherein an abdominal esophagus was created below the diaphragm. The so-called diaphragmatic pinchcock mechanism certainly could not protect the

abdominal portion of the esophagus in these dogs from regurgitation and esophagitis. Nevertheless, esophagitis did not develop and esophageal reflux was not seen radiographically.

In contrast to the observations of others, it has not been our experience that closure of the esophagus by the diaphragmatic crura may be seen esophagoscopically during inspiration. Rather, the esophageal lumen at the diaphragm seems to widen during inspiration and to narrow during expiration. Furthermore, at operation, with the fingers in the esophageal hiatus, a deep inspiration on the part of the patient does not impart a sense of digital pressure. If anything, the opening seems narrower during expiration. The observations of Lam and Kenny[12] add further evidence to negate the diaphragmatic-pinchcock theory of gastroesophageal continence. These workers noted no contraction of the diaphragmatic crus of the dog when the phrenic nerve was stimulated. Measurements of pressure indicated only a slight increase in pressure in the esophageal hiatus during stimulation of the phrenic nerve. Furthermore, Creamer[5] has shown by studies of intraluminal pressure that when esophageal reflux occurs, it takes place only during inspiration, adding further evidence that the diaphragm may play no part in maintaining the competence of the cardia. It is true that, radiographically, a swallowed column of barium is held up in the thorax during inspiration.[7] This, however, does not necessarily indicate the presence of a sphincter mechanism at the diaphragm, but may be related solely to a difference in intrathoracic and intra-abdominal pressures.

The evidence seems to point, rather, to the esophagogastric junction itself as the location of gastroesophageal continence. The studies presented herein do not indicate whether an intrinsic sphincter exists or whether the oblique entry of the esophagus into the stomach, associated perhaps with a valve flap of mucous membrane, is responsible. It has been argued that an intrinsic sphincter cannot exist at the esophagogastric junction because regurgitation does not occur after a Heller esophagocardiomyotomy. Our experimental experience and that of others[4] indicate that in the dog, at least, this procedure may be followed by esophageal reflux and esophagitis. Furthermore, gastroesophageal regurgitation and reflux esophagitis have been reported in patients after the Heller procedure.[9]

The angle of entry of the esophagus into the stomach may indeed play an important part in the prevention of esophageal reflux. Recently, Savage[15] has shown that resection of the dog's fundus leads to incompetence of the cardia, presumably by altering this angle. On the other hand, Hoag and his associates[11] have shown that esophageal reflux does not occur provided the esophagogastric junction remains intact, even though the fundus of the stomach is removed. We are in agreement with these latter workers that perhaps a physiologic, if not an anatomic, sphincter may indeed exist at the esophagogastric junction.

Caution, of course, must be used in transferring these experimental observations in dogs to an understanding of the mechanisms involved in the control of esophageal reflux in human beings. Moreover, it should be stated that the results of these experiments should not be interpreted as meaning

that diaphragmatic hernias should not be reduced. It has been shown by Aylwin[2] that when a portion of the stomach lies above the diaphragm, gastric juice puddles in this thoracic stomach pouch and reflux into the esophagus may arise from distention of this pouch by unneutralized gastric acids. Reduction of the herniated stomach to a position below the diaphragm should be carried out to prevent this pooling and reflux of gastric acids, rather than to re-establish any diaphragmatic "pinchcock mechanism" to prevent esophageal reflux.

SUMMARY

A series of experiments involving destruction of the esophagogastric junction was carried out in 30 dogs. In one group of animals the new esophagogastric junction was placed in the thorax; in another it remained in the abdomen. There was no marked difference in the postoperative incidence of esophagitis and esophageal ulceration in the two groups.

In an additional group of five dogs the production of a short segment of abdominal esophagus, the esophagogastric junction remaining intact, did not lead to significant esophagitis in this segment.

It is concluded that the diaphragm itself is not the major factor responsible for gastroesophageal continence. It is suggested that a physiologic sphincter of undefined nature resides in the region of the esophagogastric junction.

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THE USE OF PERICARDIAL GRAFTS WITH A THROMBIN-FIBRINOGEN COAGULUM IN ESOPHAGEAL SURGERY

RICHARD H. ADLER, CAPTAIN (MC) USA,* DENVER, COLO.

(From Fitzsimons Army Hospital, Research and Development Service)

ESOPHAGEAL surgery has presented certain difficulties not found in that of other sections of the gastrointestinal tract. As recently as two decades ago the risks associated with esophageal anastomoses, especially end-to-end suture, were prohibitive. The extraordinary advances in thoracic surgery techniques, endotracheal anesthesia, blood replacement, alimentary decompression, and antimicrobial therapy have eliminated most of the unfavorable factors associated with esophageal surgery. Recent investigations[5, 8, 9] have shown that the esophagus has a better blood supply than had been previously suspected. This, in turn, safely permitted wider mobilization of the esophagus resulting in less tension on the suture line. Nevertheless, two unfavorable factors remain in esophageal surgery: the absence of a true serosa, and the lack of an available anastomotic re-enforcement such as the omentum.

Based on rather extensive investigations, the basic concept of an accurate two-layer esophagoesophageal anastomosis has become established. Nevertheless, attempts to re-enforce the anastomosis continue. Deaton and Bradshaw[2] sutured a free lung-pleura graft around the suture line in dogs. They found less inflammatory reaction around the graft–re-enforced anastomoses and a degree of healing at seven days equal to that seen at twenty-one days in anastomoses without grafts. Pratt[7] abandoned attempts to use free or pedicled pleural grafts in the dog for anatomic reasons and mentioned the use of full-thickness skin grafts around the thoracic esophagus. Further details of this work were not available. Kleinsasser, Cramer, and Warshaw[1, 4, 12] sutured free peritoneal grafts around one- and two-layered esophagoesophagostomies in dogs and found that the graft–re-enforced anastomoses had relatively greater strength in resisting bursting pressure during the first five days postoperatively than those without a graft. From a recent study in dogs, McSwain and his associates[6] concluded that parietal pleura grafts, both free and pedicled, sutured with either smooth or raw surface down, effectively prevented leakage of faulty esophagoesophageal anastomoses.

Certain experiences with end-to-end esophageal suture in the repair of tracheoesophageal fistulas and localized esophageal strictures stimulated this study to find a method of supplying an artificial esophageal serosa and suture re-enforcement. A lead was taken from the earlier work of Devine[3] who successfully protected intestinal anastomoses with grafts of peritoneum using plasma clot with pressure.

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*Present address: Buffalo General Hospital, Buffalo, N. Y.

An expendable serosa-like tissue that would be readily available at thoracotomy (pericardium or parietal pleura) was selected as the graft. A simple, practical method of making a physiologic sticky coagulum for binding the graft to the esophagus without need for suturing was evolved. The results of this method as used in several series of dogs and followed up to one year will be described.

MATERIALS AND METHODS

In an effort to promote a rapid, intimate, physiologic union between the graft and the underlying esophagus, a method was developed using topical thrombin* and fibrinogen† in the form of an interposed sticky coagulum. The ability of thrombin to promote rapid adhesion of contact surfaces, especially in the presence of a source of fibrinogen (plasma), has been demonstrated.[10, 13, 14] With the use of plasma as the fibrinogen source, however, the problem of having excess fluid (serum) present between apposing surfaces following the conversion of fibrinogen to fibrin was present. Purified fibrinogen was chosen to overcome this feature, but the desiccated fibrinogen used in this study was by nature difficult to dissolve in a small volume of water or saline solution. Therefore, to obtain a more concentrated collection of fibrinogen devoid of excess fluid, a method was devised for using fibrinogen in powdered form.

The vial containing the lyophilized fibrinogen was soaked under refrigerated Zephiran solution for several days. Then, under sterile conditions, the bottle was dried and the cap removed. Glass beads were placed in the vial, a disk of copper screen was placed over the bottle opening, and a rubber bottle cap with the top partially cut away was placed over the screen. This opening was kept covered at all times, except during use, by a sterile finger cot. The bottle was then wrapped in a sterile towel and placed in a mechanical shaker until the fibrinogen was entirely in powdered form. From this time on it was kept refrigerated and wrapped in a sterile towel. It was brought out only during times of use and then returned immediately to the refrigerator. In this way, a vial could be reused over a long period of time. In vitro tests have shown no evidence of deterioration or bacteriologic contamination of the fibrinogen preparation when these precautions were carefully observed.

The smooth inner surface of the pericardial strip prepared as a graft was first covered by a thin layer of topical thrombin solution. A concentration of 2,000 NIH units per cubic centimeter (5,000 NIH units per vial dissolved in 2.5 c.c. isotonic saline solution) was found to be satisfactory. The fibrinogen powder was then added to the pericardial surface in a manner similar to shaking the contents from a salt shaker. Within several minutes the thin layer of white fibrinogen powder was dissolved with the coating of thrombin solution. The pericardial strip with the sticky coagulum covering its surface was then ready to be placed in contact with the esophagus.

A number of dogs had additional pericardial grafts applied to the esophagus using varying concentrations of thrombin solution and light and heavy coatings of fibrinogen powder. Others had extra grafts applied to the esophagus using thrombin combined with fibrinogen in concentrated solution in contrast with the powdered form.

Mongrel dogs weighing from 12 to 38 pounds were used. Intermittent positive pressure was administered endotracheally with intravenous pentobarbital sodium (Nembutal) anesthesia. Under aseptic technique, the left hemithorax was entered through the sixth intercostal space. The phrenic nerve was dissected free and a sheet of pricardium removed and trimmed free of excess adipose tissue. The pericardium was then cut into strips 1.5 to 2.0 cm. wide and of a length that allowed about a 1.0 cm. overlap of the ends encircling the esophagus. The mediastinal pleura was opened widely and the esophagus dissected from adjacent tissue. The freed segment of esophagus could be then readily lifted from its bed between two encircling umbilical tapes.

*Thrombin, topical (bovine origin). Each vial contains 5,000 NIH units of sterile, dried thrombin. Supplied by Parke, Davis & Co.

†Each vial contains 1 Gm. of sterile, dried fibrinogen (Parenogen) prepared from normal human plasma. Supplied by Cutter Laboratories.

A series of 30 dogs had free pericardial grafts applied around the esophagus to study the course of graft and coagulum without the additional factor of an underlying anastomosis. The thrombin solution and powdered fibrinogen were applied to the inner smooth surface of the pericardial strip as described. A piece of the oil silk upon which the pericardial strip had been fashioned was cut out around the pericardium. The oil silk with the pericardium was then partially wrapped around the esophagus with the coagulum and smooth pericardial surface facing the esophageal muscularis. By gentle traction the oil silk was removed from the outer pericardial surface leaving the pericardial graft adherent to the esophagus. The graft was adjusted to final position completely encircling the esophagus where it remained without sutures. After three to five minutes the esophagus was returned to its bed and no attempt was made to close the mediastinal pleura. The animals were given penicillin daily for three to seven days postoperatively, and a regular diet was resumed at once. They were sacrificed for study at daily intervals for the first two weeks and at the third and fourth week. Thereafter, elective autopsy was carried out each month up to one year. Many animals had additional pericardial grafts sutured to the esophagus without thrombin-fibrinogen coagulum for control studies.

A second group of 6 dogs had a standard two-layer end-to-end esophageal anastomosis with interrupted 3-0 silk sutures. Free autogenous pericardial grafts were applied around the anastomoses using the same method of thrombin and fibrinogen without sutures. These animals were electively autopsied at wide intervals from two weeks to twelve months postoperatively.

A third series of 6 dogs had homologous pericardial grafts applied to the esophagus by the same method using thrombin and fibrinogen. The pericardial sheets had been removed previously from another dog under sterile conditions and preserved by standard freeze-dry technique. At the time of grafting, the lyophilized homologous pericardium was reconstituted in saline solution and a section taken for histologic control. These dogs were sacrificed for study at approximately three-day intervals during the first two weeks and at one and two months postoperatively.

A final series of 20 dogs had the esophagus divided and a purposely faulty end-to-end anastomosis performed using 5 to 8 interrupted 3-0 silk sutures through all layers. The number of sutures used varied with the circumference of the esophagus, but in all cases the end of the hemostat could be dropped into the esophageal lumen between any two sutures upon completion of the anastomosis. In many instances the mucosa actually puckered outward between the sutures. In 10 dogs the faulty anastomosis was covered by a circumferential graft of pericardium using the thrombin-fibrinogen coagulum without sutures as described. In the other 10 control dogs the esophagus was returned to the mediastinum after faulty anastomosis without any graft. All dogs in this series received subcutaneous fluids for the first three days, and oral feedings were resumed on the fourth postoperative day. No animal received any antimicrobial treatment.

Most of the dogs were esophagoscoped before sacrifice. At autopsy the esophagus was distended with air and any evidence of constriction or restriction by the graft carefully noted. Careful histologic studies were made with hematoxylin and eosin, van Gieson, and Verhoeff elastic stains.

RESULTS

Within several minutes after applying the pericardial wrap with the thrombin-fibrinogen coagulum to the esophagus, fine adhesive strands of the coagulum were seen when the pericardium was purposely lifted from the esophagus. The coagulum effectively held the graft in place without sutures although the graft could be deliberately elevated or displaced. At four days postoperatively, the graft could be forcibly separated from the esophagus by traction, but it became progressively adherent thereafter. By two weeks it was intimately adherent to the muscularis, taking on the appearance of a serosa. Occasionally, a long-term graft was somewhat difficult to identify on

initial gross inspection because of its intimate incorporation with the esophagus and its concealment by adherent adjacent tissue and lung. There was no noticeable difference on gross inspection between the coagulum-fixed graft and the control graft without coagulum. The coagulum, however, caused an

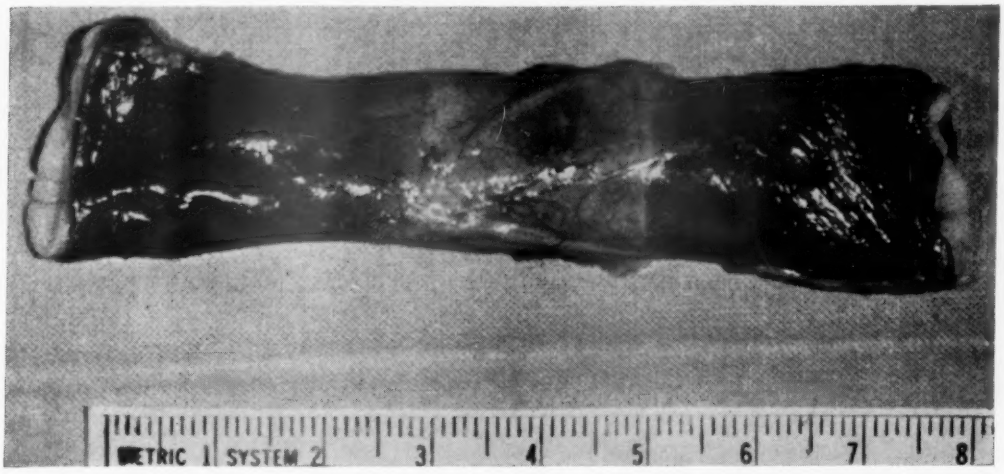

Fig. 1.—Gross specimen of esophagus with circumferential autogenous pericardial graft held in place with thrombin-fibrinogen coagulum, two months postoperatively. Graft was thin and distensible, resembling serosa.

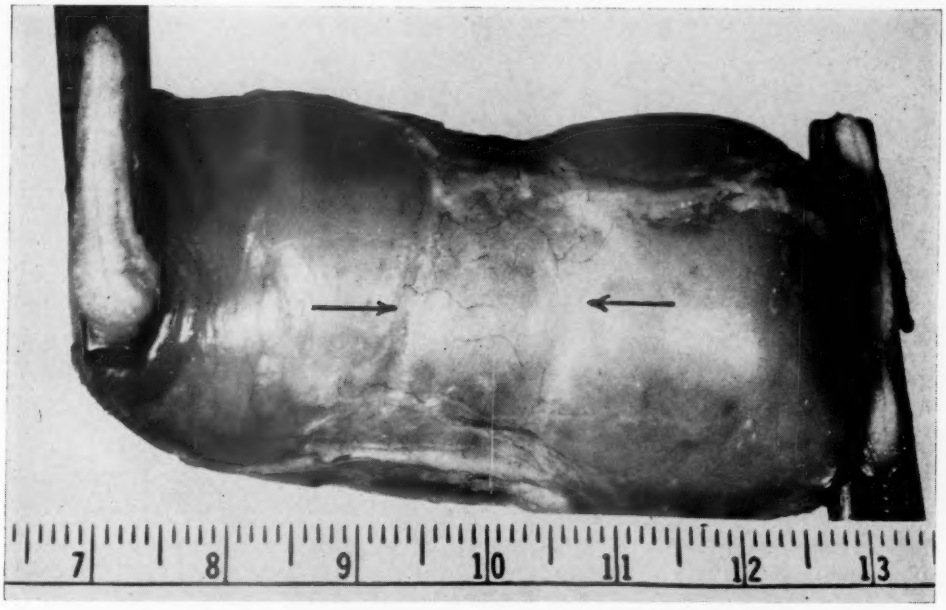

Fig. 2.—Gross specimen of isolated segment of esophagus completely distended with air, eleven months postoperatively. Arrows indicate lateral margins of circumferential antogenous pericardial graft held in place with thrombin-fibrinogen coagulum. Here, graft has only minimal effect in limiting complete esophageal distention.

earlier and more intimate union between the graft and the esophagus. A thin layer of powdered fibrinogen added to the thrombin-coated pericardium yielded better results than a heavy coating of fibrinogen powder or fibrinogen in concentrated solution.

The thrombin-fibrinogen coagulum could be readily identified histologically during the immediate postoperative period as a homogeneous layer between pericardium and esophagus. Its thickness varied with the amount of fibrinogen used in preparing the coagulum. At forty-eight hours there was a pronounced infiltration of the coagulum by blood cellular elements. By five days, capillary invasion was observed. Thereafter, the coagulum became progressively replaced by maturing vascular connective tissue so that by two weeks the coagulum was almost completely replaced by fibrous tissue binding the pericardium to the esophagus. After one month little or no difference could be observed between most of the grafts with coagulum and the controls without coagulum. The pericardium appeared to undergo little change although the exact degree of fibrous replacement was difficult to evaluate. Grafts placed over a standard two-layer esophageal anastomosis progressed the same as those placed over a normal esophagus. With grafts of homologous pericardium there was a trend toward late cellular distortion and fibrous replacement of the pericardium. During the first few weeks, however, there was no evidence of this reaction and the grafts appeared the same as the control autogenous grafts.

Early in the study, regurgitation was noted following the application of grafts around the unanastomosed esophagus of certain dogs that by nature bolted large mouthfuls of unchewed food. This was observed as early as four days postoperatively in grafts both with and without coagulum. No evidence of stricture was seen on esophagoscopy, and most of the animals were managed satisfactorily for varying periods by a finely ground diet. At later autopsy no stricture was observed, but when the graft-containing segment of the esophagus was forcefully distended with air the graft would resist complete dilatation. This type of regurgitation was practically eliminated when it was appreciated that too tight circumferential wrapping of the esophagus, especially with long overlapping graft ends, would restrict effective passage of large boluses of food. Subsequent air distention studies also showed no restriction to dilatation of the esophagus by grafts that were more loosely applied without long ends re-encircling the esophagus. The pericardium itself remained thin and pliable with little associated fibrosis, and the impression was gained that it could progressively "stretch" in time.

Eight of ten control dogs that had purposely faulty end-to-end esophageal anastomoses without graft re-enforcement died. Both animals that lived had had anastomoses performed early in the study with a somewhat less radical faulty anastomosis. At autopsy both had lung well adherent to the anastomosis; one had leakage but this remained as a small abscess localized by the adherent lung. Of the other 10 dogs that had similar faulty anastomoses with the addition of a pericardial wrap held in place only by thrombin-fibrinogen coagulum, 5 lived. Later autopsy showed the anastomoses well healed and covered by the adherent pericardial graft. Three of the 5 dogs that died had the graft still in position with an area of leakage dissecting out from under the graft: 1 died on the second day from a pneumothorax, and the other 2

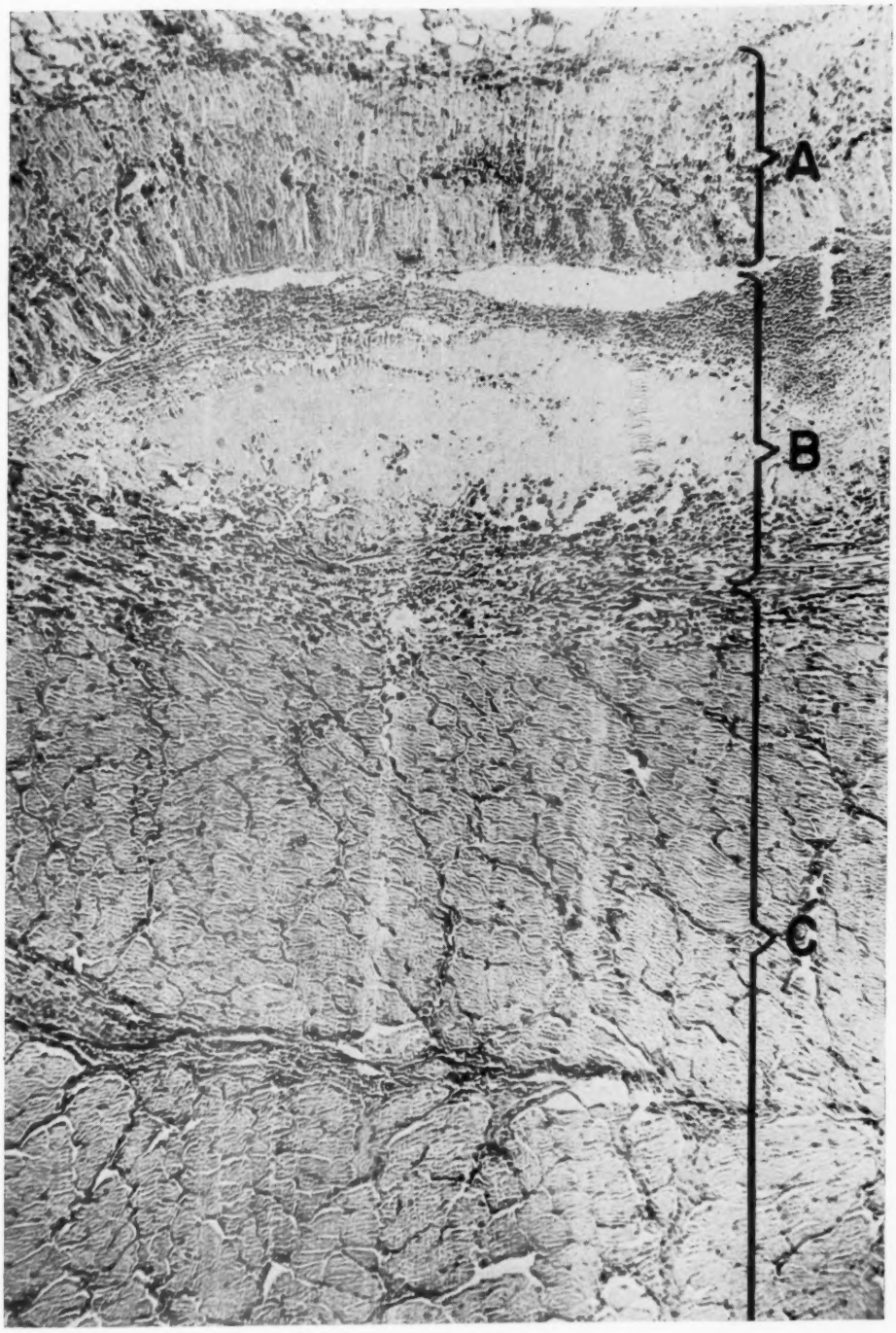

Fig. 3.—Photomicrograph four days postoperatively (hematoxylin and eosin). *A*, Autogenous pericardial graft; *B*, unusually thick layer of thrombin-fibrinogen coagulum; cellular infiltration of coagulum with beginning capillary invasion; C, esophageal muscularis. (×60.)

Fig. 4.—Photomicrograph eighteen days postoperatively (hematoxylin and eosin). *A*, Homologous pericardial graft; *B*, thrombin-fibrinogen coagulum replaced by vascular connective tissue; *C*, esophageal muscularis. (×60.)

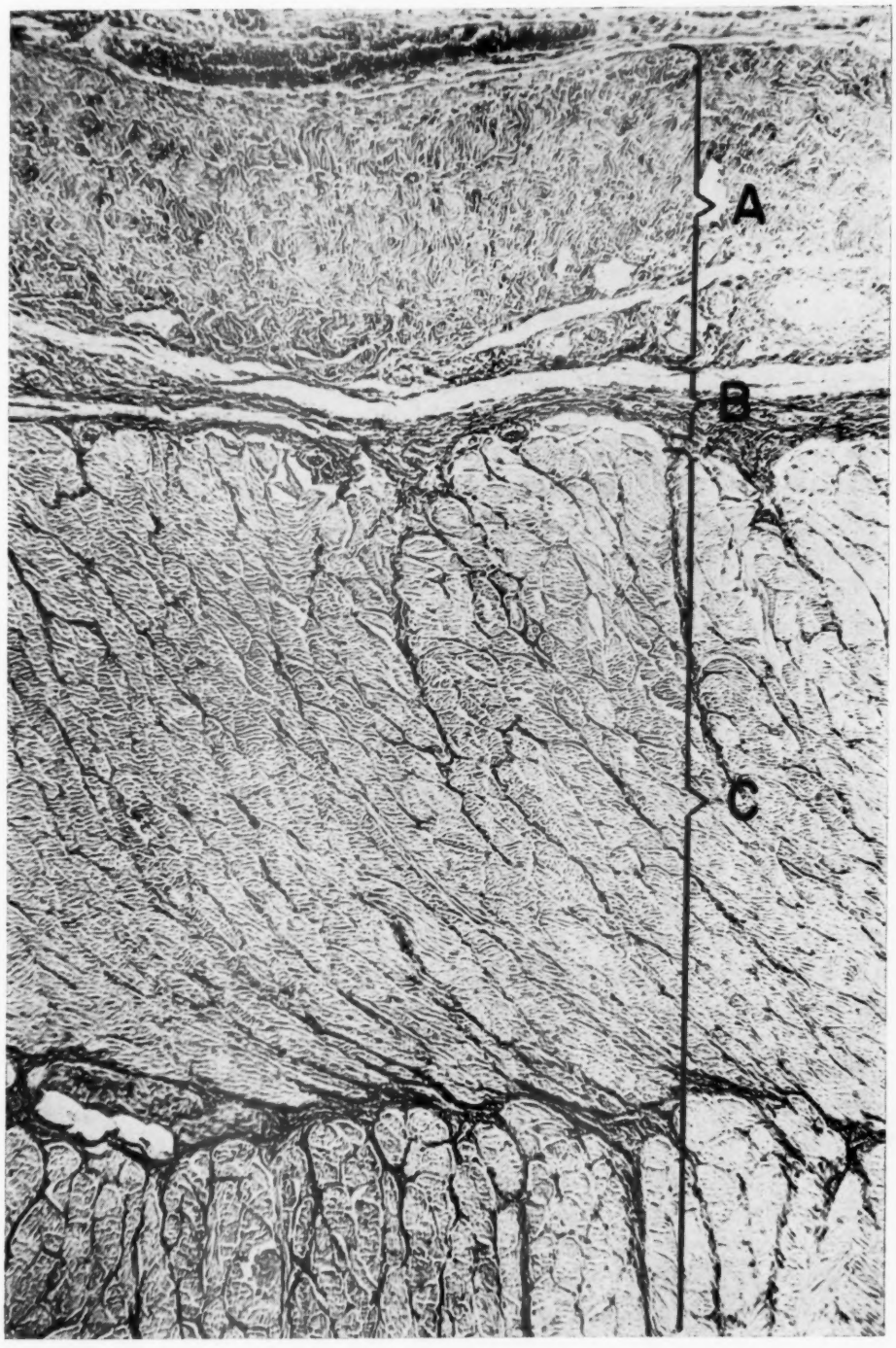

Fig. 5.—Photomicrograph ten months postoperatively (hematoxylin and eosin). *A*, Autogenous pericardial graft; B, site of thrombin-fibrinogen coagulum replaced by vascular connective tissue; *C*, esophageal muscularis. (×60.)

from mediastinal and pleural infection. Neither of the remaining 2 dogs in the group had the graft adherent to the esophagus. Both had diffuse mediastinitis and pleuritis with a large amount of sanguinous pleural fluid. The excess bleeding resulted from imperfect hemostasis of the poorly anastomosed esophageal ends; this was felt to be the cause of the pericardial grafts not adhering.

DISCUSSION

The procedure of applying a re-enforcing graft of pericardium around an esophageal anastomosis proved to be effective and practical. The graft and coagulum without sutures completely protected the faulty end-to-end anastomosis in 5 of 10 dogs whereas 8 of 10 control dogs without a graft died and another developed a localized abscess. Had certain factors, commented upon earlier, been appreciated during this phase of the study, the protective effect of the graft and coagulum might have been greater.

Pericardium rather than parietal pleura was selected as the graft because of the thin delicate pleura encountered in most dogs of the size used in this study. The pericardium would not need to be used in the human being who has a more substantial parietal pleura than the dog. The infant, however, has a parietal pleura less suitable for grafting. To avoid opening the pericardium in the infant, a section of homologous pleura or pericardium might be used as a graft to re-enforce an esophageal anastomosis such as seen following repair of a tracheoesophageal fistula. Our limited experience with the use of such homologous grafts preserved by lyophilization would suggest that they are as effective during the early postoperative period as autogenous grafts. Because the homologous pericardium appears to undergo fibrous replacement by the host, the eventual effect of this upon the growing esophagus of the infant needs further study.

At thoracotomy, with the esophagus in the collapsed state, care must be taken to avoid wrapping the esophagus too tightly. Also, the encircling ends of the graft should overlap only a short distance or the graft may exert a local restricting effect upon the otherwise distensible esophagus. The pericardium itself persisted as a thin, distensible structure intimately adherent to the esophagus and apparently capable of adaptive "stretching" with time. If care is taken in applying the graft around the esophagus, postoperative regurgitation should not be a problem in the human being.

The preparation of a sticky coagulum of fibrinogen and thrombin was simple and required little additional time at surgery. The purified bovine thrombin and human fibrinogen were well tolerated in the dog. The coagulum was most effective when made up of a thin layer of powdered fibrinogen added to the thrombin solution. It was rapidly replaced by a vascular connective tissue that intimately bound the graft to the esophagus. There was no significant evidence of increased fibrosis or stricture resulting from the use of the coagulum. A word of caution should be added: the method of sterilization of the fibrinogen by ultraviolet radiation might not inactivate completely

the virus of homologous serum jaundice if it was present in the original plasma. Whether this is of sufficient practical importance to limit the use of this fibrinogen preparation in the human being cannot be stated for certain at this time.

The thrombin-fibrinogen coagulum caused a more rapid and intimate adherence of the graft to the esophagus than seen in control grafts with suture and no coagulum. It must be emphasized, however, that the pericardium does not become immediately "vulcanized" onto the esophagus nor does the coagulum rapidly set as a cementlike glue. Although coagulum-fixed grafts remained in position without sutures, two did float free as a result of excess bleeding or leakage beneath them. This was seen only when surrounding a purposely faulty end-to-end anastomosis. Conceivably, excess intrapleural fluid in the immediate postoperative period might also dislodge the graft. Therefore, in clinical use, several sutures anchoring the graft to the esophagus might be advisable if extensive postoperative oozing is anticipated. The coagulum would eliminate the need for more painstaking suturing.

Patch grafts of pericardium with the coagulum also effectively adhered to the esophagus. Such patches can be used to re-enforce the suture lines following esophagotomy. The coagulum has also been shown to be effective in causing adherence between apposing smooth serosal surfaces such as two lobes of a lung or a lung and the chest wall. In the same way, it will promote adherence between pericardium and smooth serosal surfaces such as the trachea, bronchial stump, myocardium, and gastroesophageal or jejunoesophageal anastomoses.[11]

SUMMARY

1. A method was described for preparing a sticky coagulum made from topical thrombin and fibrinogen. The coagulum effectively promoted rapid adherence between free pericardial grafts and the esophagus without added sutures.

2. Grafts held in place by the thrombin-fibrinogen coagulum functioned satisfactorily without untoward reaction and were effective in re-enforcing esophageal suture lines. Lyophilized homologous pericardial grafts exerted a similar protective action.

3. The results found in several series of dogs were presented and possible applications of the method briefly discussed.

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THE USE OF SURGICAL PITUITRIN IN THE CONTROL OF ESOPHAGEAL VARIX BLEEDING

An Experimental Study and Report of Two Cases

John H. Kehne, M.D., Felix A. Hughes, M.D., and Michael L. Gompertz, M.D., Memphis, Tenn.

(From the Surgical Research Laboratory, Thoracic Surgical Section, and Gastro-enterology Section, Veterans Administration Medical Teaching Group Hospital)

Case 1.—L. W., a 36-year-old white man, was first admitted to Kennedy Veterans Administration Medical Teaching Group Hospital from August 5 through October 15, 1953, with complaints of epigastric heaviness, bloating, nausea, vomiting, and weight loss of four to five months' duration. He described ten years of heavy alcoholism with periods of inadequate nutrition. During that hospital stay the liver was reported to be palpable 10 cm. below the costal margin. A diagnosis of portal cirrhosis was established by liver profile and liver biopsy. He was readmitted on April 14, 1954, because of jaundice and hematemesis. Esophageal varices were demonstrated by barium swallow and confirmed by esophagoscopy. He was discharged on May 13 after refusing definitive surgery for relief of portal hypertension, but was readmitted forty-eight hours later because of further hematemesis.

Examination revealed a slightly obese, pale, white man with slight icteric tinting of the sclerae. The liver was palpated 6 cm. below the costal margin. Large veins were noted over the upper abdomen radiating over the anterior chest wall. The following laboratory values were reported: Serum bilirubin 0.95 mg. per cent; thymol turbidity 2.7 units; alkaline phosphatase 4.03 Bodansky units; prothrombin time 100 per cent; plasma protein 6.3 Gm.; albumin 3.3 Gm.; globulin 3.0 Gm.; cephalin flocculation 3 plus forty-eight hours; stool examinations positive for occult blood; hemoglobin 12.7 Gm.; urine urobilinogen 1:128.

Course.—A diagnosis of portal cirrhosis with bleeding esophageal varices had been previously established and all efforts during this hospitalization were directed toward control of the esophageal bleeding. Following admission, the patient went into hepatic failure with deepening jaundice and ascites but slowly improved, so that operative intervention could be considered. He was transferred to the Thoracic Surgical Section for consideration of splenorenal shunt. On July 27, 1954, exploration of the abdomen through a left combined thoracoabdominal incision revealed a hobnail liver and a mild splenomegaly. The spleen was removed and a splenorenal shunt performed. Splenic venous pressure prior to the shunt was found to be 370 mm. of water. The patient's immediate postoperative course was uneventful until August 5, the ninth postoperative day, when he developed pallor, epigastric fullness, and vomited 200 c.c. of clotted blood. One thousand cubic centimeters of blood was transfused. On the following morning, a second major hemorrhage occurred which was controlled by the insertion and inflation of a Sengstaken-Blakemore tube. On August 9, a third major hemorrhage occurred with the loss of 1,000 c.c. of blood. It was felt that the splenorenal shunt had occluded and that a portacaval shunt should be carried out. On August 10, abdominal exploration revealed thrombosis of the splenorenal shunt and marked peritoneal reaction over the vena cava which made

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portacaval anastomosis impossible. The hepatic artery distal to the gastroduodenal artery and left gastric artery were ligated. The patient's general condition remained good until August 17, when he again developed weakness, pallor, and vertigo followed by the passage of tarry stools. This hemorrhage subsided without specific therapy, but recurred on August 23. At 11:30 P.M., September 2, he again complained of epigastric fullness and an estimated 1,500 c.c. of blood was vomited in three hours. Blood transfusions were started and inasmuch as a Sengstaken tube was not available and the patient's condition was considered critical, 20 international units of surgical Pituitrin* diluted with 10 c.c. of normal saline solution was given intravenously during a period of ten minutes. There was no change in systemic arterial pressure. No further emesis occurred and nausea and epigastric fullness, which had characterized all preceding hemorrhages, failed to reappear. A total of 1,500 c.c. of citrated blood was transfused. On September 13, a massive hematemesis again occurred which ceased following the injection of 20 units of surgical Pituitrin intravenously. During this hemorrhage, 1,500 c.c. of blood was given. On September 14, he again developed mild nausea and vomited 1,000 c.c. of blood. No evidence of further bleeding could be found following the intravenous injection of 20 units of surgical pituitrin. On September 20, the patient was transferred to the Medical Service where his next hematemesis occurred on September 26, with the measured loss of 750 c.c. of blood. Subjective and objective evidence of hemorrhage disappeared after the injection of 20 units of Pituitrin. Further episodes of bleeding occurred on Nov. 19 and Dec. 9, 1954, and Feb. 8, Feb. 19, and March 8, 1955, but subsided without specific therapy except for blood replacement. From December, 1954, until February, 1955, the patient was in hepatic failure, but thereafter slowly improved. On March 8, 1955, he again vomited 1,000 c.c. of blood and was given 10 units of Pituitrin intravenously with apparent control of the hemorrhage. Thereafter, the patient went into hepatic coma and expired March 9.

Pathologic examination revealed Laennec's cirrhosis with ascites and esophageal varices. Organized thrombus was found in the portal vein (with extensive intrahepatic thrombosis), splenic vein, and superior mesenteric vein. The splenorenal shunt was completely occluded.

COMMENT

The initial trial of intravenous Pituitrin(S) for the control of esophageal varix bleeding was prompted in a moment of desperation when the reported patient appeared to be exsanguinating rapidly. The selection of Pituitrin(S) was based on knowledge of the usefulness of this drug for the control of pulmonary hemorrhage as described by Trimble and Wood.[7] Although the bleeding was quantitatively great, the injection of 1 c.c. of surgical Pituitrin (20 international units), diluted to a volume of 10 c.c. with normal saline solution, intravenously during a period of ten minutes resulted in no fall in systemic arterial pressure and apparent control of the bleeding. The epigastric fullness, nausea, and vomiting which were associated with each major hemorrhage failed to recur, blood replacement became effective, and facial color rapidly improved. On four subsequent occasions, following or during major hemorrhages, subjective and objective manifestations of bleeding failed to recur after the injection, and indicated more than a coincidental relationship between the injection of Pituitrin and the cessation of bleeding. No recurrence of major hemorrhage occurred within twenty-four hours after each injection of Pituitrin.

LITERATURE

A review of the literature failed to reveal any report of similar experience with bleeding esophageal varices, although Bainbridge and Trevor (1917),[1]

*Parke, Davis & Company, Detroit, Mich.

Clark (1928),[3] McMichael (1932),[5] and Katz and Rodbard (1939)[4] had demonstrated in experimental animals that intravenous Pituitrin or Pitressin caused an elevation of hepatic arterial pressure and an abrupt fall in portal pressure. Katz and Rodbard[4] explained this relationship by the action of Pitressin on the preportal arteries causing a marked splanchnic vasospasm with resultant decrease in portal flow, decrease in liver volume, and fall in the recorded portal venous pressure. Clark[3] felt that the major site of action of Pituitrin was in the capillaries of the splanchnic region, thereby decreasing the inflow of blood into the portal system. McMichael,[5] by studying the portal pressure responses to intravenous Adrenalin and Pituitrin, felt that a capillary system must exist within the liver between the hepatic artery and the portal vein before the sinusoids. This concept of the intrahepatic presinusoidal arteriovenous shunt has been introduced as an explanation of control of bleeding esophageal varices following celiac arterial ligation by Rienhoff[6] and Berman and Hull.[2] Although blood pressure tracings were introduced with each reported experimental study of the portal pressure-Pituitrin relationship,[3-5] a quantitative expression of this decrease in portal pressure following intravenous Pituitrin was not included, and no studies were reported in experimental animal preparations with elevated portal pressures. Additional studies were indicated relative to these points.

METHOD

Four healthy adult dogs anesthetized with intravenous pentobarbital sodium were utilized in the acute experiments. Arterial pressures were recorded on the Phipps-Bird kymograph from the gastroduodenal and femoral arteries. The portal pressure was obtained by introducing a polyethylene catheter into the portal vein via the dorsal vein of the inferior lobe of the pancreas and the femoral vein was similarly catheterized and pressures recorded on water manometers. Each animal was heparinized prior to the cannulation of vessels. Portal pressures were corrected to the measured level of the portal vein.

Preliminary studies indicated that the injection of 4 units of surgical Pituitrin per minute for five minutes elicited an elevation of arterial pressure. If given more rapidly the initial rise in arterial pressure was followed by a precipitous fall in pressure to shock levels, followed by rapid recovery. It was also demonstrated that 4 units of Pituitrin(S) per minute, 8 units per 2 minutes, and 20 units per 5 minutes all elicited the same degree of arterial and venous pressure change. Accordingly, all studies were made following the injection of 4 international units of Pituitrin(S) diluted to 2 c.c. with normal saline solution and injected intravenously during a one-minute period.

In Series I the response of healthy adult dogs to the intravenous injection of 4 units of Pituitrin per minute and in Series II the responses of animals having a 75 per cent ligation of the inferior vena cava above the diaphragm one month previously were studied.

RESULTS

Series I.—(Intravenous injection of 4 units Pituitrin(S) in normal dogs.) Four animals were included in this series and each demonstrated similar pressure responses. Immediately following the injection, the arterial pressure rose abruptly and was associated with a rapid fall in portal pressure, the total response being complete within two minutes. The portal pressure remained depressed for a period of about twenty-five minutes and then slowly rose for an additional fifteen to twenty minutes, usually stabilizing at a level slightly less

than the original portal pressure. The response of Dog No. 2526 is graphically recorded in Fig. 1. During the slow rise in portal pressure a gradual fall in arterial pressure also occurred. The response to a second injection of surgical

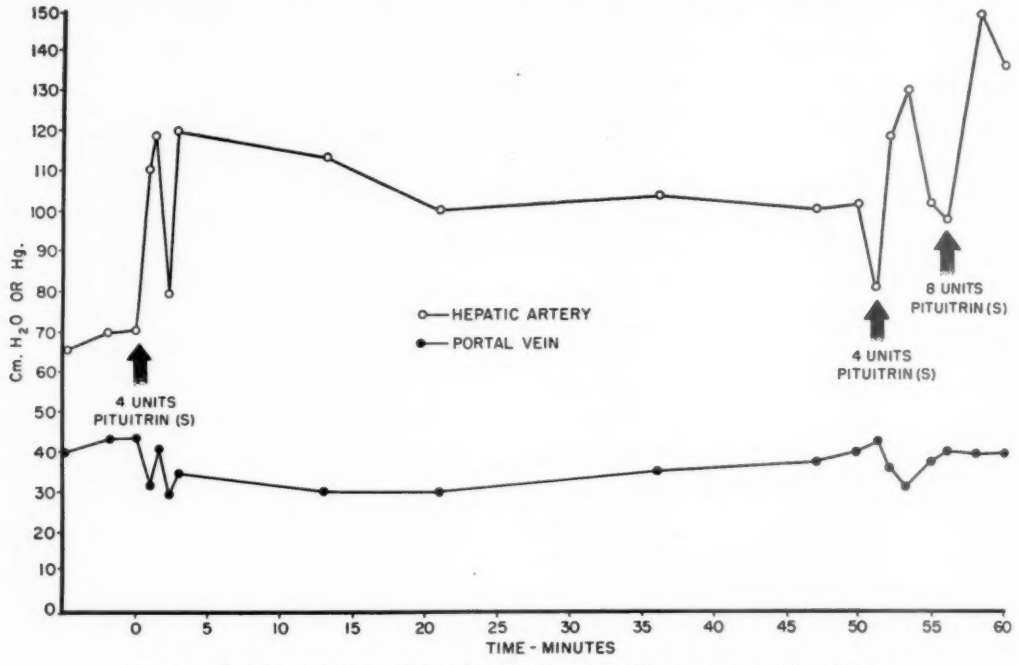

Fig. 1.—Portal pressure Pituitrin(S) study. Normal dog, No. 2526.

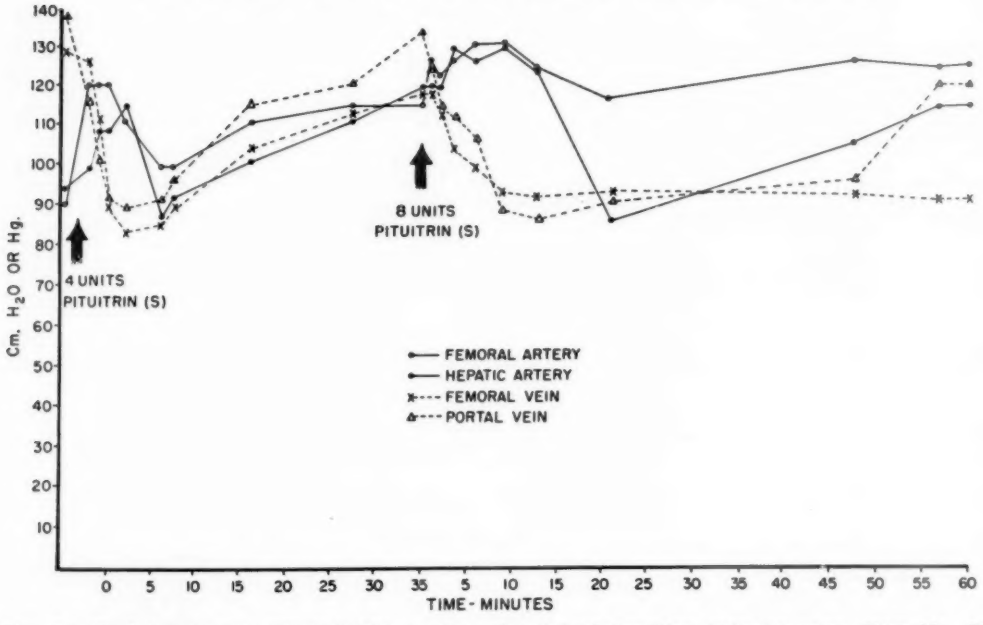

Fig. 2.—Portal pressure Pituitrin(S) study. Partial obstruction inferior cava Dog No. 2301.

Pituitrin fifty minutes after the initial injection is recorded. The rise in arterial pressure and a fall in portal pressure is apparent, although the latter is maintained for less than five minutes. The arterial response was also rapidly

dissipated. Following recovery, a third injection of 8 units of Pituitrin(S) provoked a rise in arterial pressure although the portal pressure remained unchanged. The last two injection studies indicate the importance of tachyphylaxis. A summary of the portal pressure changes observed in normal dogs following the intravenous injection of four units of surgical Pituitrin is recorded in Table I. Percentage decreases in portal vein pressure were found to be 20, 20, 28.5, and 33 per cent in the four animals studied.

TABLE I. PORTAL PRESSURE—PITUITRIN(S) STUDY
(NORMAL DOGS)

DOG NO.	CONTROL PORTAL PRESSURE CM. H_2O	POSTINJECTION PORTAL PRESSURE CM. H_2O	PER CENT DECREASE PORTAL PRESSURE
2239	6.0	4.8	20
2526	4.1	2.8	33
2233	5.6	4.0	28.5
2566	5.0	4.0	20

Series II.—(Partial obstruction of inferior vena cava in dogs.) Four animals were studied and each had similar arterial and venous responses to the injection of Pituitrin(S). When intravenous Pituitrin was injected immediately following acute ligation of the inferior vena cava, it was found that no change was produced in portal or femoral vein pressure due to the absence of available collateral channels to allow decompression distal to the point of occlusion. Accordingly, the studies were delayed for one month following 60 to 75 per cent occlusion of the vena cava in order to allow the development of adequate venous collateral pathways. Control portal pressures in four dogs prior to the injection were recorded as 13.8 cm., 11.2 cm., 15.8 cm., and 11.5 cm. of water (Table II). Each of the four animals had similar early changes in the arterial and venous pressures. The major fall in portal pressure occurred in each case during the first two minutes from the beginning of the injection and was greater than those recorded in the normal animals. Percentage decreases of 36.2, 36, 30, and 30 per cent of normal were recorded (Table II).

TABLE II. PORTAL PRESSURE—PITUITRIN(S) STUDY
(PARTIAL OBSTRUCTION INFERIOR VENA CAVA—DOG)

DOG. NO.	CONTROL PORTAL PRESS. CM. H_2O	POSTINJECTION PORTAL PRESS. 120 SEC. CM. H_2O	PER CENT DECREASE PORTAL PRESS.	PORTAL PRESS. MAXIMAL DECREASE CM. H_2O	PER CENT DECREASE PORTAL PRESS. (MAXIMAL)
2301	13.8	8.8	36.2	8.8	36.2
2317	11.2	7.8	36	7.6	37.7
2387	15.8	10.8	30	8.6	44.8
2336	11.5	8.0	30	5.8	49.5

In two cases, Animals No. 2387 and No. 2336, slow additional falls occurred in portal pressure which reached their lowest levels six minutes from the beginning of the injection. The maximal percentage decrease in portal pressure in these animals was recorded as 44.8 and 49.5 per cent (Table II).

Fig. 2 presents a graphic expression of the pressure changes in the femoral and hepatic arteries and femoral and portal veins in an animal with a partial obstruction of the inferior vena cava. The major elevation in arterial pressure occurred in the femoral artery and it is to be noted that the hepatic arterial pressure paralleled the femoral pressure curve. A return to the normal range was recorded in thirty-five minutes. Abrupt falls occurred in both femoral and portal venous pressures and were recorded within two minutes from the beginning of the injection. After ten minutes of maximal depression, a slow recovery occurred during a period of thirty-five minutes. Following recovery of both arterial and venous pressures, a second injection of 8 units of Pituitrin(S) elicited the same percentage fall in venous pressure, indicating that the pressure changes are not augmented by increasing the dosage of Pituitrin.

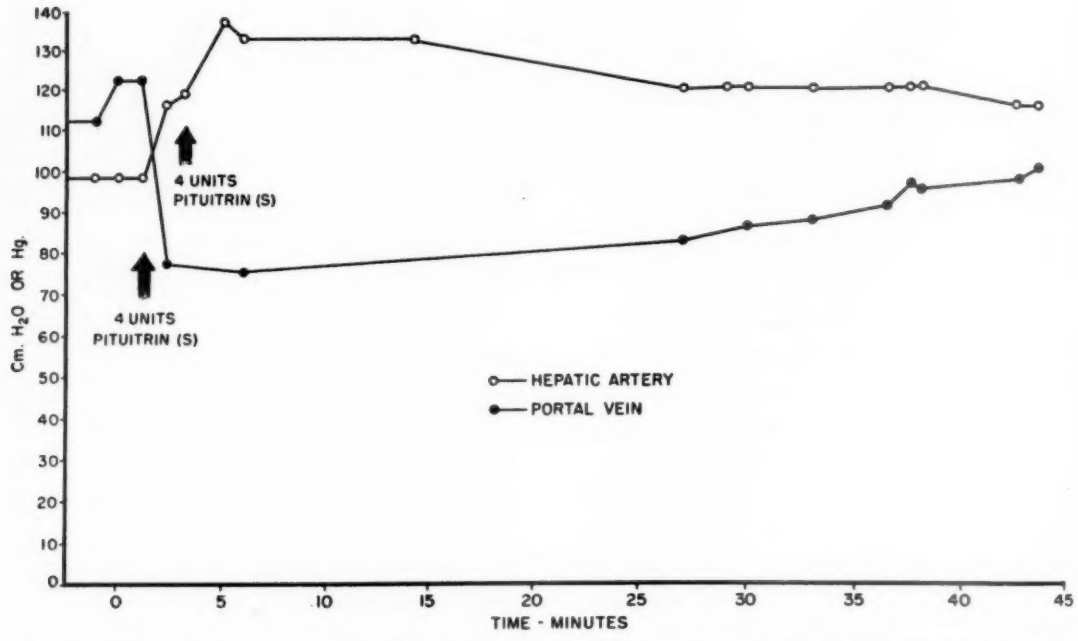

Fig. 3.—Portal pressure Pituitrin(S) study. Partial obstruction inferior vena cava, Dog No. 2317.

Fig. 3 records the hepatic artery and portal vein pressures (Dog No. 2317) following the injection of four units of Pituitrin. Abrupt immediate changes were noted in both arterial and venous pressure. When the maximal fall occurred in portal pressure, the injection of four additional units of Pituitrin(S) failed to elicit any additional significant decrease in portal pressure, although an increase in arterial pressure occurred. In this study, stabilization of both arterial and venous pressures was nearly complete after forty-five minutes.

DISCUSSION

It has been previously demonstrated experimentally that the intravenous injection of Pituitrin produced an abrupt fall in portal pressure.[1, 3-5] This study has demonstrated average decreases of 25.3 per cent in portal pressure

within two minutes from the onset of injection in four normal dogs. Following partial obstruction of the inferior vena cava and the development of adequate collateral venous circulation in four animals, an intravenous injection of 4 units of Pituitrin(S) precipitated an average decrease of 33 per cent in portal pressure within two minutes. Two of these animals had delayed average decreases of 47 per cent in portal pressure within six minutes. Admittedly, the experimental studies differ considerably from the vascular problems associated with cirrhosis. However, when the area of varix erosion is small, the intravenous injection of 20 units of Pituitrin(S) is followed by objective and subjective manifestations of cessation of bleeding, as indicated on five occasions in Case 1. The results in this case suggest that in cirrhosis a similar fall of portal pressure occurred following the injection of Pituitrin(S). Although it has been demonstrated experimentally that the period of portal pressure depression is less than one hour, this appeared adequate for local thrombosis to have occurred at the site of varix bleeding.

It is interesting to note in the Berman and Hull[2] study of triple celiac ligation for the control of ascites and bleeding varices that portal pressure changes following ligation have been variable. They report portal pressure decreases in nine patients following triple celiac arterial ligation varying from 8 to 41 per cent with an average of 27 per cent for the group. In the discussion of the paper, three additional cases were reported with changes in portal pressure varying from 12 to 40 per cent. Reynolds' reported patient[2] was found to have a portal pressure of 320 mm. of water prior to triple celiac ligation, 280 mm. of water following ligation, and returned to the normal range within thirty to forty minutes. It is felt that the portal pressure changes described here following the injection of surgical Pituitrin, although transitory, satisfactorily parallel the reported results of celiac axis ligation.

Various theories have been presented to explain the fall in portal pressure following the injection of Pituitrin. Katz and Rodbard[4] felt that the fall was due to marked splanchnic vasospasm. Clark[3] felt that the primary vascular block was in the capillaries of the splanchnic region and McMichael[5] stated that his data suggested a block in the intrahepatic presinusoidal arteriovenous shunts which his data indicated were present. Berman[2] stated that sodium fluorescein studies of the lower circulation indicated the presence of an arteriovenous or venovenous shunt mechanism in the liver. Although both mechanisms could be active in producing the fall in portal pressure following the injection of Pituitrin, it is apparent from the pathologic findings that portal vein thrombosis eliminated the intrahepatic shunt theory in Case 1 and that the fall in portal pressure could only be explained by splanchnic vasospasm.

The experimental data suggested that the response to a smaller dosage of surgical Pituitrin should be the same. It was noted in the second case to be reported that 10 units of Pituitrin intravenously satisfactorily controlled varix hemorrhage on two occasions. When injected at the rate of two units per minute for ten minutes, arterial pressure changes were avoided although dermal blanching was commonly seen. The experimental data indicate that the

response to injection is immediate and should evidence of hemorrhage persist for one hour, esophageal tamponade is indicated. No additional effect can be obtained by giving more Pituitrin (Fig. 3). Intravenous surgical Pituitrin has been effective in the control of esophageal hemorrhage in one other case reported as follows.

CASE 2. N. R., a 58-year-old white man, was admitted to Kennedy Veterans Administration Medical Teaching Group Hospital on April 5, 1955, because of hematemesis. A diagnosis of chronic alcoholism and cirrhosis had been established during previous admissions by laboratory studies and liver biopsy.

On the day of admission, the patient vomited approximately one pint of fresh and clotted blood. Examination at the time revealed marked pallor and an enlarged liver palpable 6 cm. below the costal margin. Tarry stool was present in the rectum. The hemoglobin was 9.6 Gm.

Following admission, he was treated conservatively until the evening hours when he vomited repeatedly large amounts of blood. After vomiting 1,500 c.c. of fresh red blood at 9:30 P.M., he was given 0.5 c.c. (10 units) of Pituitrin(S) diluted with 10 c.c. of normal saline solution. Although there was no further subjective or objective manifestations of bleeding, a Sengstaken-Blakemore tube was inserted two and one-half hours later at which time only 30 c.c. of old blood could be aspirated from the stomach. The tube was removed after thirty-six hours. He again vomited fresh blood at 5:15 P.M. on April 14 and blood transfusions were started. After passing four large melanotic stools he was given 10 units of Pituitrin(S) intravenously. He refused to have the Sengstaken tube inserted and showed no further signs of bleeding as evidenced by clinical observation and stabilization of the hemoglobin and hematocrit values. Large saccular esophageal varices were demonstrated by barium swallow and esophagoscopy. On May 6 he was transferred to the Thoracic Surgical Section for consideration of a shunt procedure. Exploratory laparotomy on May 10 revealed a hobnail liver and marked splenomegaly. Splenectomy was performed anticipating a splenorenal shunt, but this could not be accomplished due to splenic vein friability. Large saccular varices over the high gastric cardia and lower esophagus were stripped and excised. The patient's postoperative convalescence was uneventful. There has been no recurrence of the hematemesis although large residual esophageal varices have been demonstrated as high as the middle third of the esophagus.

CONCLUSION

1. The intravenous injection of four units of surgical Pituitrin in normal dogs has been found to produce an average decrease in portal pressure of 25.3 per cent within two minutes of the onset of injection.

2. Following partial ligation of the inferior vena cava of four dogs with resultant elevation of portal pressure, 4 units of Pituitrin(S) produced an average immediate decrease in portal pressure of 33 per cent and an average delayed fall of 47 per cent within six minutes in two animals.

3. Two clinical cases are presented in which esophageal varix bleeding was controlled on a total of seven occasions by the intravenous injection of 10 to 20 units of Pituitrin(S) at the rate of two units per minute.

4. The laboratory and clinical observations reported here are felt to justify the use of surgical Pituitrin in the emergency treatment of esophageal bleeding.

5. The use of surgical Pituitrin in the control of esophageal bleeding is suggested as a form of adjunct emergency therapy and not as a substitute for tamponade.

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THE USE OF AUTOGENOUS SKIN GRAFTS TO REPAIR ARTERIAL DEFECTS

An Experimental Study

Charles Horton, M.D.,* Frank Campbell, M.D., Richard Connar, M.D., Albert Smith, M.D., and Kenneth Pickrell, M.D., Durham, N. C.

(From the Department of Plastic Surgery, Duke University School of Medicine and Duke Hospital, and Veterans Administration Hospital)

THE replacement of abnormal segments of arteries with normal functioning tissue is a fundamental problem of vascular surgery. From the first arterial transplantation by Jabolay[19] in 1896 to the present day, various authors have been occupied in this search and have proposed many substitutes for arterial tissue.

The most favorable substitute to date has seemed to be the homogenous arterial graft, first reported to be used successfully in human beings by Gross and associates[11] in 1948. However, many difficulties have been discovered when this type of graft is employed clinically.[1, 28, 41] First, the donor vessel must be obtained from an ideal subject within a few hours after death. Second, if the graft is not used immediately, it must be stored, which requires further equipment and handling.[4] The problem of viable versus nonviable preservation of the artery graft remains unsettled; however, if viable preservation is desired, more extensive equipment, handling, and personnel are needed for the process.[28] Third, certain immunologic factors of the host which are as yet unknown act on the nonautogenous graft, preventing the permanent growth of the structure, and presumably convert the graft to a nonviable strut which functions until it is replaced by fibrous tissue.[32] Fourth, although the grafts function well for the first few months, certain sclerotic and degenerative changes may occur within the area of the homogenous segment if the graft is observed over a period of years.[1] Fifth, the homogenous graft is apparently unable to grow, and should not be used in children where enlargement of the artery above and below the graft is anticipated.[20, 22]

The use of heterogenous grafts has been reported by Hufnagel,[16] but, in theory, these grafts would seem to have all of the disadvantages of the homogenous graft, plus an even more violent immunologic potential. Several investigators have recorded the use of paraffin-lined silver tubes,[40] glass tubes,[27] Vitallium tubes,[2] tubes of methyl methacrylate,[17] polyethylene,[26] and Vinyon "N" cloth,[42] to repair arterial defects. Again, it is obvious that these substitutes cannot grow, and the danger of intolerance of the body to the foreign material is ever present.

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*Present address: 611 Medical Arts Building, Norfolk, Va.

Autogenous arterial grafts serve as excellent repair material for arterial defects, but are limited in use because of the lack of available donor vessels. However, several ingenious methods employing small arterial segments sutured together to form a larger graft have been proposed for use only in small defects of arteries.[18, 35]

Autogenous vein grafts appear to function satisfactorily in defects of smaller arteries, but the repair of larger vessels requires sacrifice of the inferior vena cava, which is not desirable. Other workers report dilatation and aneurysm formation when vein grafts are sutured into defects of large arteries.[21]

Vascular repair with a pericardial graft has also been attempted, but this appears to dilate when used as replacement material for arterial defects.[36]

Autogenous fascia has been used in the past to prepare patches for the repair of small areas of arterial wall loss.[30] These apparently function well, although further investigation would seem desirable in this instance.

In theory, there is little doubt but that autogenous materials would be preferable in the reconstruction of tissue defects throughout the body, irrespective of location.[28, 29, 37] In consideration of this, an experiment was begun to study the use of autogenous skin grafts to repair arterial defects. At first it would seem that the use of skin to replace arterial tissue is not practical; however, when it is considered that skin is a most versatile and adaptable organ that has been grafted on many sites other than on defects of the external surface of the body, such usage becomes more feasible. Autogenous skin has been grafted successfully in the mouth,[39] orbit,[10] vagina,[31] urethra,[25] and on the urinary bladder.[6] It has been used on ileostomy stumps,[24] in mastoid cavities,[12] in hernioplasties,[3] as filler substances for contour losses,[33] as thoracic wall lining,[34] on the trachea,[7] esophagus,[9] diaphragm,[8] and in various other locations. Horton and associates[13] have reported the experimental behavior of the growth of skin on the liver, spleen, kidneys, aorta, ureter, bladder, stomach, intestines, and parietal peritoneum. Experimental reconstruction of the ureter with split-skin grafts has been performed, in which the grafted skin adapted to function as a substitute for the transitional epithelium which it replaced.[14] Horton and co-workers[15] also described the growth of skin in the thorax, on the lungs, diaphragm, esophagus, trachea, aorta, heart, pericardium, and parietal pleura of dogs. In each instance, the skin graft grows and remains viable. From these experiments, the use of autogenous skin to repair arterial defects was suggested.

EXPERIMENTS

Adult mongrel dogs varying in weight from 5 to 15 kilograms were anesthetized with intravenous sodium pentobarbital. If an intrathoracic procedure was contemplated, an endotracheal tube was inserted. The skin of either the abdomen or chest was shaved, prepared with hexachlorophene and Zephiran, and sterile drapes were applied. Using the Brown Electro-dermatome, a thin (0.008 inch) split-thickness graft was elevated and a dermal graft cut from the resulting split-skin donor site. The dermal graft was cleaned of excess fat and placed in a 1:10 heparin-saline solution. In abdominal aorta experiments, the abdomen was then entered through a midline incision, the aorta exposed, and

mobilized from the renal arteries to the bifurcation. In instances in which the thoracic aorta was utilized, the chest was entered through an intercostal incision, and the descending thoracic aorta mobilized for a distance of 6 to 8 cm. proximal to the diaphragm.

When a patch was to be applied, the aorta was occluded with Potts clamps, and a segment varying in size from 1 by 2 cm. to 1.5 by 4 cm. was excised from the anterior wall. The dermal graft was removed from the heparin solution and trimmed to a size slightly larger than the defect in the aorta. Continuity of the vessel was re-established by anchoring the graft in the previously created defect with stay sutures of 5-0 arterial silk at each of the corners, followed by a continuous over-and-over suture around the circumference of the patch. The patches were placed with the fatty side outermost, that is, the epithelial side in contact with the blood stream, in some of the experiments. In other experiments, the patch sides were reversed so that the fatty side of the graft was innermost. After the clamps were removed, peritoneum or pleura was sutured over the patch, and the abdomen or chest and the skin donor site were then closed with interrupted sutures of 4-0 black silk.

While application of thoracic aorta patch grafts necessitated occlusion of the aorta for relatively short periods of time, the more time-consuming circumferential thoracic aorta grafts posed a greater technical problem in that irreversible spinal-cord damage was found to occur in dogs when the thoraic aorta blood flow was interrupted for a period of time over fifteen to twenty minutes. Because of this, a hollow Lucite stent was prepared and tied into position to bridge a circumferential defect of the thoracic aorta. The blood flow continued through the stent, while a dermal graft was sutured loosely over the defect, the graft extending to normal aorta over each side of the stent. Loose pleural folds were sutured over the graft site, and the chest and donor site closed with continuous sutures of 4-0 black silk.

When a circumferential abdominal graft was to be performed, the aorta was cleaned and mobilized, and a stent comparable in size with the aorta was selected. The dermal graft was then folded over the stent, leaving the desired surface of the graft outermost, and two rows of continuous sutures of 5-0 black silk were placed to join the graft edges and produce a skin tube. At this point, Potts clamps were applied to the aorta and a segment of vessel was excised and discarded. The tubed skin graft was then removed from the stent and sutured to the cut ends of the aorta, utilizing several types of continuous sutures, including the everting mattress, the continuous over-and-over, and the Blalock suture. Following this, the clamps were removed, all bleeding was controlled, and loose folds of peritoneum were sutured over the graft area. The abdomen and donor site were closed as usual with sutures of 4-0 black silk.

When grafts were placed around the external surface of the aorta, the approach to the vessel and the mobilization of the artery was as previously described. The graft was then wrapped around the artery, leaving the subcutaneous surface innermost and in contact with the wall of the artery. Following this, the dermal graft was sutured in position with interrupted sutures of 5-0 black silk. All incisions and donor sites healed uneventfully throughout the entire experiment. A total of 51 dogs were operated upon in this series, and arteriograms were made at intervals to follow the progress of the grafts. The arteriograms were performed by (1) inserting a polyethylene tube through the femoral artery, by (2) direct needling of the aorta, or (3) by injection of the opaque material into the external jugular vein. Three hundred thousand units of procaine penicillin was given to each experimental animal for a period of twenty-one days following the operation.

RESULTS

Ten dogs had dermal skin grafts with the dermal surface inward, placed in the abdominal or thoracic aorta to repair circular defects of the anterior vessel wall measuring from 1 by 2 cm. to 1.5 by 2.5 cm. in size (Table I).

Four of the dogs died within five days following operation, from thrombosis at the graft site. Of the remaining 6 dogs, 2 were sacrificed forty-five days after surgery. The other 4 dogs had normal arteriograms 265, 221, 210, and 202 days postoperatively, and were sacrificed 497, 380, 221, and 210 days

TABLE I. AORTA PATCH GRAFTS, DERMAL SURFACE INWARD

DOG NO.	SITE	NO. OF DAYS OF GROWTH	SIZE OF GRAFT (CM.)	RESULT
3	Abdomen	2	1 × 2	Died; thrombosis
4	Abdomen	45	1.5 × 1	Sacrificed; graft simulated normal aorta
5	Abdomen	3	1.5 × 1	Died; thrombosis
6	Abdomen	497	1 × 2	Sacrificed; graft simulated normal aorta
8	Abdomen	5	1 × 2	Died; thrombosis
9	Abdomen	2	1 × 2	Died; thrombosis
12	Thorax	380	1 × 2	Sacrificed; graft simulated normal aorta
13	Thorax	221	1.5 × 2.5	Sacrificed; graft simulated normal aorta
16	Thorax	210	1.5 × 2.5	Sacrificed; graft simulated normal aorta
18	Thorax	45	1.5 × 2.5	Sacrificed; graft simulated normal aorta

TABLE II. AORTA PATCH GRAFTS, FATTY SIDE INWARD

DOG NO.	SITE	NO. OF DAYS OF GROWTH	SIZE OF PATCH (CM.)	RESULT
33	Abdomen	338	1.5 × 2	Sacrificed; normal appearance; arteriogram normal
34	Abdomen	300	1.5 × 2.5	Sacrificed; normal appearance; arteriogram normal
36	Abdomen	73	0.5 × 2	Sacrificed; normal appearance; arteriogram normal
42	Abdomen	240	1.5 × 2.5	Sacrificed; normal appearance; arteriogram normal
14	Thorax	160	1.5 × 2	Sacrificed; normal appearance; arteriogram normal

TABLE III. CIRCUMFERENTIAL AORTA GRAFTS, DERMAL SIDE INWARD

DOG NO.	SITE	NO. OF DAYS OF GROWTH	LENGTH OF GRAFT (CM.)	RESULT
11	Abdomen	140	3	Early thrombosis; no recanalization
15	Abdomen	3	2.5	Thrombosis; death
17	Abdomen	150	3.5	Early thrombosis; no recanalization
20	Abdomen	110	3	Early thrombosis; no recanalization
23	Abdomen	2	2	Thrombosis; death
24	Abdomen	7	3	Thrombosis; death
25	Abdomen	2	3.5	Thrombosis; death
26	Abdomen	2	3	Thrombosis; death

following surgery. The patches appeared to be quite similar to normal aorta wall, and had normal-appearing endothelium covering the inner surface. Microscopically, the wall was composed of tough but pliable fibrous tissue, lined with endothelium. The junction between normal aorta and the skin

graft patch was not remarkable, since glistening endothelium covered the graft (Figs. 1 and 2). Only a few remnants of adnexal glands persisted after the sixth month to reveal the origin of the grafted tissue.

Autogenous dermal patch grafts with the fatty side inward were used to repair aorta defects measuring from 0.5 by 2 to 1.5 by 2.5 cm. in 5 dogs. Each dog survived the operative procedure, and arteriograms were made in each instance, before sacrifice of the dogs 73, 160, 240, 300, and 338 days postoperatively (Fig. 3). Grossly and microscopically these patches appeared in no way different from those which were placed with the dermal side inward (Fig. 4, Table II).

Fig. 1.—Dermal skin patch in abdominal aorta. Note the endothelium lining.

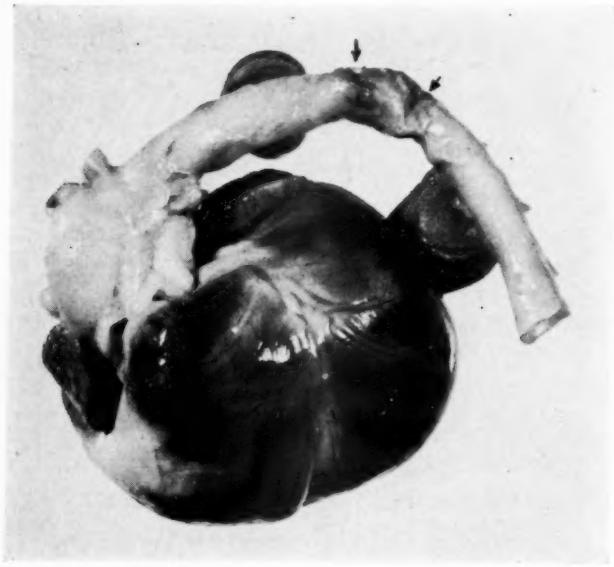

Fig. 2.—Dermal skin patch in thoracic aorta.

When circumferential dermal skin grafts with the dermal surface inward were used to replace arterial segments in dogs, thrombosis within the graft site occurred in each instance. Eight such grafts were constructed, and each resulted in thrombosis in the early postoperative period (Table III). Three of these grafts were allowed to remain in position for 140, 150, and 110 days each, but in no instance did recanalization occur. Microscopically, sections taken through the thrombosed areas revealed only irregular fibrous tissue, with no evidence of a channel persisting.

In 14 dogs, dermal grafts of autogenous skin with the fatty surface inward were used to reconstruct circumferential arterial channels varying in length from 2.5 to 5 cm. (Table IV). Three dogs died in the early postoperative period as a result of distemper. At the time of death, four, five, and

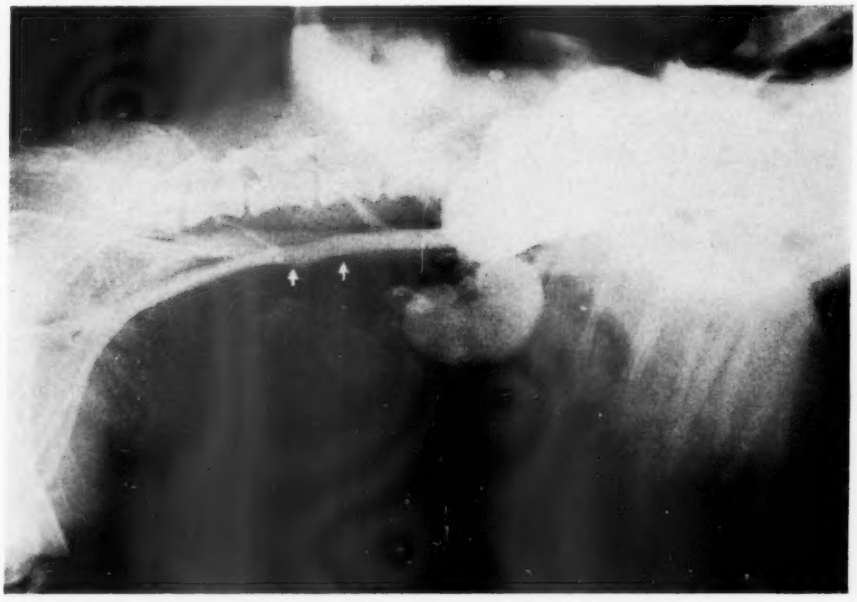

Fig. 3.—Arteriogram of circumferential dermal graft with fatty side in, replacing abdominal aorta.

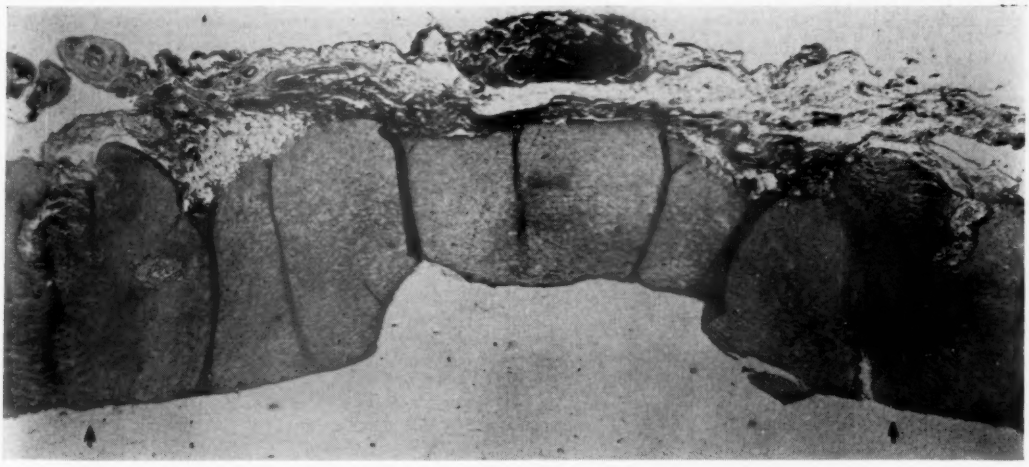

Fig. 4.—Late microscopic appearance of bisected dermal patch of aorta wall. The skin patch extends between the suture line noted on each side of the specimen.

seven days after surgery, each graft was apparently living. Three other circumferential dermal grafts, with the fatty side inward, developed thrombus formation beginning at the distal suture line. One of these grafts remained

functioning for three months postoperatively, as demonstrated by a normal arteriogram at that time. Following the arteriogram a thrombus developed and the animal was sacrificed 144 days postoperatively.

Similar circumferential grafts functioned satisfactorily in 8 dogs for a period of 36, 61, 78, 132, 148, 188, 223, and 243 days each, before the animals were sacrificed and the specimens obtained (Figs. 5 to 8).

TABLE IV. CIRCUMFERENTIAL AORTA GRAFTS, FATTY SIDE IN

DOG NO.	SITE	NO. OF DAYS OF GROWTH	LENGTH OF GRAFT (CM.)	RESULT
27	Abdomen	148	5.0	Sacrificed; small stricture at suture line, but channel intact
28	Abdomen	5	4.0	Died; graft intact and patent
29	Abdomen	132	3.5	Sacrificed; small stricture at suture line, but channel intact
30	Abdomen	7	2.5	Died; graft intact and patent
31	Abdomen	144	3.5	Normal arteriogram at 3 months; thrombosis developed at 4½ months; graft endothelialized
35	Abdomen	4	2.5	Suture broken; acute hemorrhage 4 days postoperatively
37	Abdomen	36	4.0	Sacrificed; graft intact and patent
38	Abdomen	243	3.0	Sacrificed; graft intact and patent
39	Abdomen	61	3.0	Sacrificed; graft intact and patent
41	Abdomen	56	2.5	Sacrificed; thrombus filling lumen of graft was noted
43	Abdomen	43	2.5	Died; thrombus filling lumen of graft was noted
44	Abdomen	78	3.0	Sacrificed; graft intact and patent
45	Abdomen	223	3.0	Sacrificed; graft intact and patent
46	Abdomen	188	3.0	Sacrificed; graft intact and patent

TABLE V. REINFORCEMENT GRAFTS

DOG NO.	SITE	NO. OF DAYS OF GROWTH	TYPE	RESULT
51	Abdominal aorta	180	Split-skin graft wrapped around exterior of aorta	All grafts grew well and strengthened aorta wall; no cyst formation
52	Abdominal aorta	170		
53	Abdominal aorta	170		
54	Abdominal aorta	160		
1	Abdominal aorta	130		Cyst present; no constriction of lumen
A-3	Abdominal aorta	90	Dermal graft wrapped around exterior of aorta	All grafts grew well and strengthened aorta wall; no cyst formation
A-4	Abdominal aorta	96		
A-5	Abdominal aorta	84		
2	Abdominal aorta	210		
10	Thoracic aorta	162		
36	Abdominal aorta	70		
40	Abdominal aorta	26		

In 12 dogs the aorta was dissected free for a distance of 2 to 3 cm., and a supporting jacket of skin was sutured around the vessel (Table V). Five of these dogs had grafts of split skin placed on the aorta, and were observed over periods varying from 130 to 180 days. One graft only formed a unilocular cyst around the aorta, presumably from the longitudinal edges of the circumferential skin graft growing around and up in the shape of a horseshoe, to

ultimately unite in the mid-portion. There was no marked diminution of the lumen in this case. The remaining 4 split-skin grafts did not form cysts but instead persisted as living portions of the artery, adding thickness to the vessel wall.

Seven circumferential dermal grafts placed as a sleeve around the aorta were observed for periods varying from 26 to 210 days. Each of these skin grafts became an integral portion of aorta wall, adding definite strength to each artery. The grafts all grew evenly and without distortion. Small

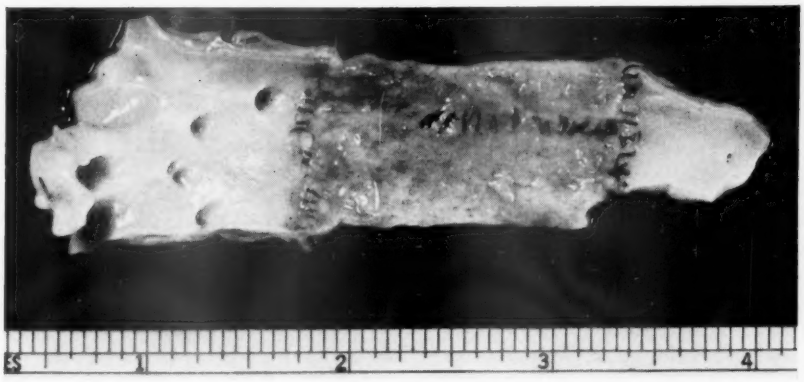

Fig. 5.—Appearance of early circumferential dermal graft replacing abdominal aorta. Endothelium has not covered the fatty interior of the graft.

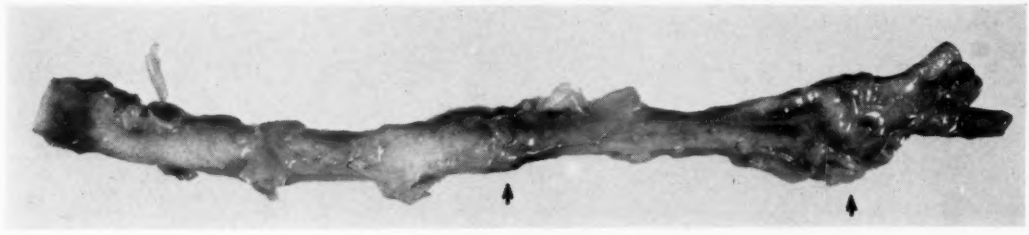

Fig. 6.—Appearance of the exterior circumferential dermal graft replacing abdominal aorta (fatty side in). Note the smooth, well-vascularized external surface.

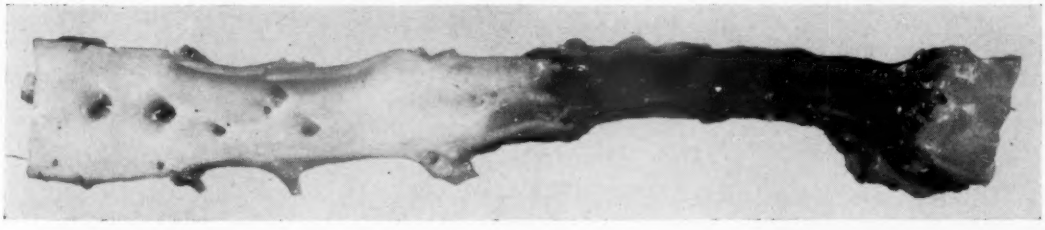

Fig. 7.—Appearance of interior of circumferential dermal graft.

microscopic intradermal cystic spaces were present early in each graft; however, these decreased in number and disappeared at about the third or fourth month, when the epithelial elements of the graft began to disintegrate. After the sixth month, the graft was a tough fibrous layer, with only microscopic evidence of epithelial origin as shown by the fragments of a few adnexal glands.

One patch graft of autogenous split-thickness skin was used in an attempt to repair an aorta defect measuring 1 by 2 cm. in size. It was immediately apparent that this type of graft was excessively thin to withstand the trauma of the aorta blood flow. As might have been expected, this graft ruptured on the second postoperative day, and the dog expired. One thoracic aorta graft

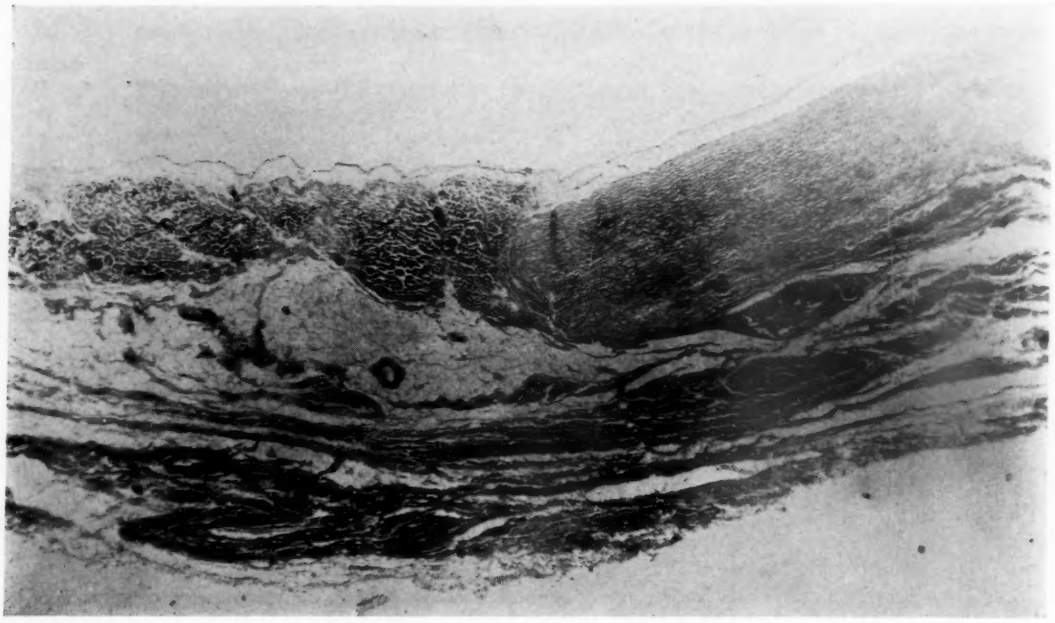

Fig. 8.—Early circumferential dermal graft replacing aorta. Note the endothelium extending over the graft.

Fig 9.—Interior of circumferential dermal graft (dermal side in) replacing thoracic aorta. The suturing of the graft in this instance did not require great care, since the stent did not allow bleeding through the suture line.

was constructed over a hollow Lucite stent, previously described, and followed for ninety-three days postoperatively until the experimental animal was sacrificed, and it was determined that the skin tube was viable and intact (Fig. 9). It was again noted that microscopically the graft was composed of tough fibrous tissue with little evidence of epithelial tissue persisting.

DISCUSSION

The utilization of skin to repair arterial defects in dogs has been accomplished. Although de Takats[5] and Lowenberg[23] have previously used cutis grafts to reinforce aneurysms in human beings, and Sako[36] has reported the reinforcement of vein and pericardial grafts with jackets of skin in dogs, no record has been found in the literature of the work presented in this experiment.

Except for the immediate mortality, caused in most cases by thrombosis at the graft site, the relationship of the dermis to the blood stream did not appear to be of importance. In those dogs in which the epithelial surface of the graft faced the blood stream, a higher incidence of immediate thrombosis was noted, the reasons for which were not clear. The gross and microscopic appearance of the grafts in the surviving animals did not seem to be influenced by this factor.

In the circumferential groups, new and important mechanical considerations were introduced and, since this study was not primarily undertaken to solve these problems, they need only be mentioned. The fundamental difficulty was the difference in tensile strength, elasticity, and quality between the dermis and the aortic wall to which it was sutured. The dermis layer in dogs is pliable, easily stretched, and lacking in the tough elasticity of the normal aorta. This resulted occasionally in turbulence within the graft itself, and unsatisfactory function with delayed thrombosis either at the anastomoses or within the graft.[38] This unfavorable situation did not preclude, however, a satisfactory graft, especially in larger dogs, in which most of the functioning grafts were obtained. Grossly the dermal grafts appeared to grow well, over the time interval studied, as a functioning part of the aorta wall. No progressive aneurysm formation was encountered. Gross examination of the functioning grafts before sacrifice of the animals revealed that they appeared amazingly similar to the color and contour of the normal aorta. After sacrifice of the animals, when the adjacent aorta had contracted, a quality apparently not possessed by the skin graft, the grafts appeared somewhat thin and pliable as compared with the aortic wall.

Grossly the inner surface of the graft was always smooth and shiny, approximating the appearance of normal intima. Microscopically this surface in the larger grafts seemed to be derived, in part, from differentiating fibroblasts, while in the smaller grafts actual downgrowth of endothelium was observed. The difference in the two coverings of the inner surface of the grafts would appear to be academic.

The microscopic progress of events in the surviving grafts was interesting. Persistence of the original graft, as proved by the demonstration of minute fragments of adnexal elements, could be recognized for varying lengths of time, well past one year in some of the patch grafts. It is probable that portions of the collagenous and fibrous elements persisted longer, but this could

not be proved under the conditions of this experiment. For practical purposes, however, it could be concluded that the graft itself did not contribute notably to the permanent support of the aortic wall. Instead, a remarkable ingrowth of dense fibrous and collagenous tissue covered and reinforced the entire skin graft, and usually seemed to be derived primarily from the aorta itself. Occasionally this may have originated from the graft or possibly from the periaortic tissue. This new growth of supporting fibrous tissue bore a variable relationship to the surviving graft elements, when these were identifiable; sometimes the adnexal structures were internal to the new fibrous tissue growth, sometimes external. It is interesting to note that the graft placed about a plastic tube and protected from the stimulating pressure of the aortic blood stream did not undergo this reinforcement.

It can be seen, therefore, that autogenous grafts, in this case the dermal skin graft, undergo much the same sequence of events as that described for homologous grafts. The process is reconstructive in nature, and is perhaps more marked in instances when a tenuous substance is used to bridge an aortic defect than when a more substantial material is utilized. Another interpretation of our data would be that in the lack of an immunologic necrobiosis, and with viable elements from an autogenous graft persisting, the reparative process is more immediate and effective. Either reason would explain the results of this experiment; namely, that the rather unsubstantial dermis layer of a dog's skin makes a fairly adequate replacement of an aortic wall defect. This study does not allow one to conclude that autogenous materials have more than a theoretical advantage over homologous, or even heterogenous materials for aortic grafting. Indeed, the end result would seem to be the same, and would depend more upon the remarkable ability of the body and the aorta to repair itself than upon the material used. That such long-term advantages of autogenous material exist cannot be concluded from these data. Further study is indicated to determine if growth of the grafts can be expected, and if sclerosis or aneurysm formation will occur.

Although reinforcement cutis grafts have previously been used on abdominal aneurysms, no prior experimental observations have been made on the histologic appearance of the skin over various periods of time. Dermal grafts appear to be vastly superior to split-skin grafts as artery wall reinforcement material. Besides possessing greater strength, they also would seem never to form unilocular cysts, as had one split-skin graft in this experiment. When autogenous material is used as a supporting jacket for aorta wall, the graft tissue lives and grows, nourished by new extrinsic vascular channels which appear to be permanent. Microscopically, the viable dermal graft changes as expected from that of the normal section of skin to tissue with minute cystic spaces derived from the accumulation of material in the adnexal glands. Ultimately the grafts became mature compact fibrous tissue without evidence of surface origin, and add definite living reinforcing material to the aorta.

SUMMARY AND CONCLUSIONS

1. Data on the use of autogenous skin grafts to repair arterial defects in dogs are presented.

2. Ten dogs had a patch graft of dermal skin with the dermal side inward used to repair the defect of the anterior aorta wall. Four of the patches were the site of a fatal thrombosis, while the remaining six patches grew and functioned normally for periods up to 265 days.

3. Five dogs had a patch of autogenous dermal skin graft with the fatty side inward used to repair a defect of the anterior aorta wall. All five grafts survived and functioned normally.

4. Tubular dermal skin grafts with the dermal surface inward were used to replace circumferential segments of aorta in ten dogs. All ten grafts thrombosed and did not recanalize.

5. Fourteen tubular dermal skin grafts with the fatty surface inward were used to replace circumferential segments of the abdominal aorta in dogs. All fourteen grafts functioned well initially; however, three dogs died of uncontrolled extrinsic pathology in the early postoperative period, and three other dogs died of delayed thromboses. The remaining eight grafts survived and functioned normally.

6. In twelve dogs, jackets of skin were placed to reinforce the aorta wall. These grew and functioned without difficulty, adding strength to the vessel wall.

7. Autogenous dermal substitutes for aorta wall appeared to survive, adapt, and to be reinforced by a secondary layer of fibrous tissues, which is probably derived from the aorta.

8. Further study on the use of autogenous skin grafts in vascular surgery would seem to be indicated.

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EXPERIMENTAL RECONSTRUCTION OF THE AORTIC BIFURCATION

BERNARD FISHER, M.D.,* RALPH WILDE, M.D., PERRY ENGSTROM, M.D., AND EDWIN R. FISHER, M.D., PITTSBURGH, PA.

(From the Departments of Surgery [Section of Experimental Surgery] and Pathology, and the Addison H. Gibson Laboratory, University of Pittsburgh)

WITH the increased demand for aortic grafts in the last few years, numerous experimental and clinical methods have been devised in an attempt to circumvent the shortage of available graft material. Compilation autografts from segments of splenic,[13] femoral,[17] and subclavian[19] arteries have been used to bridge short defects in the thoracic and abdominal aortas of dogs. Likewise, autogenous dermal grafts,[6, 11] tissue tubes,[16] and rectus sheath[9] have been used for the same purpose. The use of synthetic materials has been enthusiastically described by Blakemore,[1] Shumacker,[20] Edwards,[5] Deterling,[4] Hufnagel,[12] and Shumway.[21] However, all these experimental studies have been concerned with the replacement of straight segments of dog aortas. Only Shumway, using polyvinyl sponge, constructed aortic bifurcation grafts in 4 dogs.

Over a year ago, in attempting to explore ways in which the shortage of aortic bifurcation grafts could be met, it was considered that a possible source of homografts from pediatric necropsies was being overlooked. Naturally, the difference in size of the lumen of the aortas and iliacs taken at autopsy from children made the bifurcation useless in adults requiring such a graft. However, since the aorta, particularly the thoracic segment, in youngsters is frequently about the size of the adult common iliac, it was felt that perhaps by merely raising the crotch following resection of the distal aorta and bifurcation these vessels could be used to advantage.

The following study was undertaken to evaluate the practicability of two different methods of reconstruction of the aortic bifurcation using straight segments of aorta from young, incompletely grown animals grafted into fully mature, adult dogs.

Although Sawyer[15] demonstrated superior results for freeze-dried grafts over fresh homografts, when implanted into the abdominal aorta between the renal arteries and trifurcation, it was of interest to know whether this was also true for vessels of smaller caliber such as used in this study. Thus, each type of bifurcation reconstruction was evaluated using fresh and freeze-dried homografts. All animals have been followed for at least six months, and 75 per cent for one year.

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*John and Mary Markle Foundation Scholar.

METHOD

Forty-five adult mongrel dogs, of both sexes, averaging 21 kilograms in weight, were used for this study. The animals were anesthetized with pentobarbital sodium. The abdomen was opened through a long midline incision and the aorta was completely mobilized distal to the renal arteries. The vessels forming the trifurcation were likewise mobilized to provide an adequate cuff for resection and anastomosis. Construction of a new aortic bifurcation was accomplished using two different techniques.

Group A.—In this group of 23 dogs the reconstruction was made as shown in Fig. 1. In 13 dogs the homografts used were fashioned from fresh vessels and in 10 from freeze-dried aortas. All grafts in this study were removed from puppies and immature young dogs weighing between 3 and 6 kilograms. Those used fresh were stored for no longer than twenty-four hours in a balanced salt solution containing antibiotics at 4° C. In most instances they were used on the day removed. Lyophilized vessels were prepared within forty-eight hours after removal. The technique of freeze-drying used in this laboratory has been described.[7]

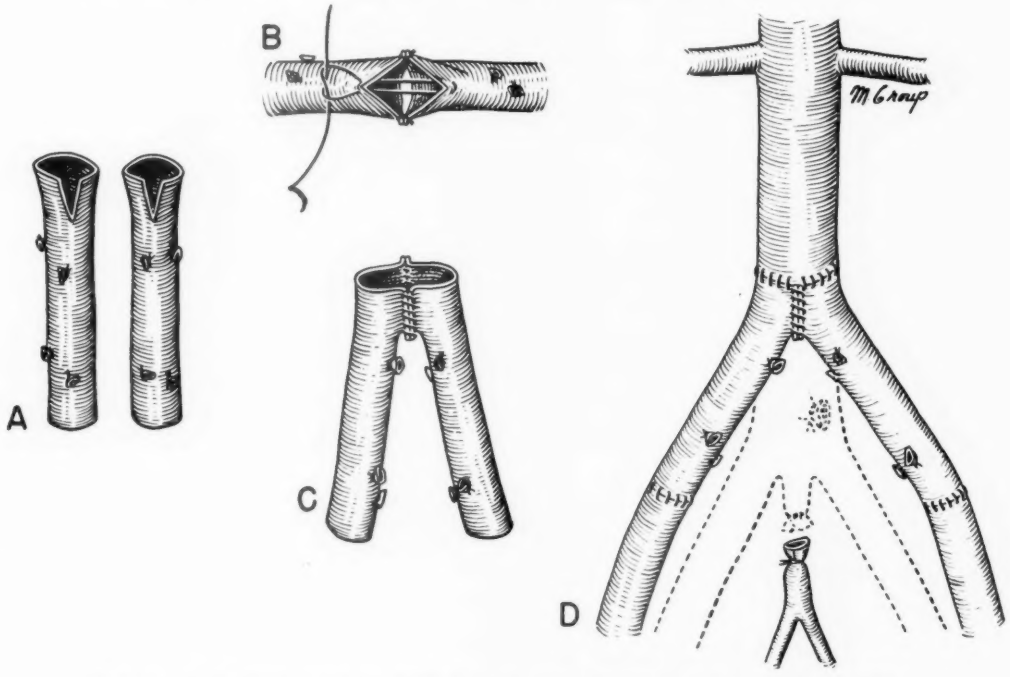

Fig. 1.—Technique used in Group A to reconstruct the aortic bifurcation.

The graft was fabricated at the operating table in a few minutes from two segments of aorta of equal length (3.5 to 4.0 cm.) (Fig. 1, *A*), the distal lumens of which closely approximated those of the iliacs. A small V-shaped wedge was removed from one side of the proximal end of each segment. Using three everting sutures, the corners of the two V's were approximated (Fig. 1, *B*), and the two limbs of the V were sutured together with continuous everting stitches (Fig. 1, *C*). This newly fashioned bifurcation graft was inserted in the following sequence: the left iliac was divided between vessel clamps and the left limb of the graft anastomosed to it; the right iliac was handled similarly; and, lastly, the middle branch of the trifurcation was ligated and transected and the aorta clamped and severed distal to the renal arteries. The graft-aortic anastomosis was completed using continuous over-and-over sutures of 5-0 silk. All iliac anastomoses were performed with a similar suture, except that the lumen of each was quadrangulated. The appearance of the graft in place is demonstrated by Fig. 1, *D*. The posterior peritoneum was sutured over the graft and the abdomen was closed in layers.

Group B.—In this group fresh grafts were inserted in 10 animals and lyophilized vessels in 12. A single straight section of puppy aorta approximately 8 cm. in length was used. The branches were ligated and, using a technique identical to that in Group A, the two iliac anastomoses were performed (Fig. 2, *A* and *B*). An elliptical opening was made in the side of the graft so that the long axis was comparable to the diameter of the host aorta. Using a continuous over-and-over suture, an end-to-side aortic-graft anastomosis was performed (Fig. 2, *C*).

Following operation, femoral pulses were palpated daily for the first month and approximately once every two weeks thereafter. At intervals, arteriograms were performed. Grafts were examined and suitable histologic studies were made in all animals that died or were sacrificed. At the end of one year, animals were explored and sections of the graft removed for study. Reanastomosis was performed and further prolonged observations will be made.

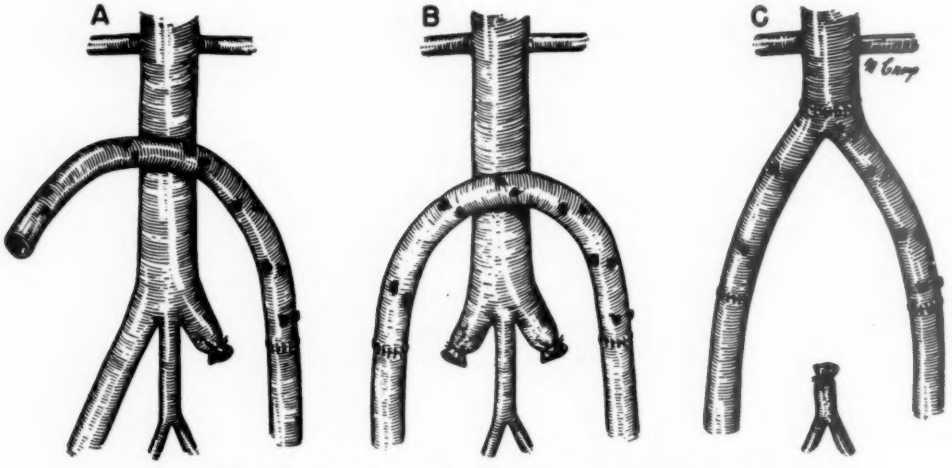

Fig. 2.—Method of aortic bifurcation reconstruction in Group B.

RESULTS

All results were evaluated as being clinically excellent or poor. If bilateral femoral pulses persisted throughout the length of observation of the animal, aortograms showed freely patent vessels, and at autopsy or operation there was no evidence of thrombosis, they were placed in the former category. On the other hand, death of the animal, or thrombosis, partial or complete to one or both limbs of the graft, was considered a poor result. The microscopic findings concerning the presence or absence of degenerative change in the fresh and lyophilized grafts after one year will be given separate consideration.

Group A.—As shown in Table I, 6 of 13, or 46 per cent of the animals in which fresh homografts were implanted, had excellent results. Of the 7 considered poor, one animal died of hemorrhage five days postoperatively and at autopsy a large amount of retroperitoneal clot was found with a small opening in the lateral aspect of the graft-aorta anastomosis not related to the suture lines which fabricated the graft. The other 6 animals demonstrated thromboses. In all, the thromboses involved the graft-iliac anastomoses and not the new bifurcation. In 4 dogs the thrombosis was unilateral and was estimated as having completely occluded the vessel by 3, 7, 8, and 8 days postoperatively as determined

by loss of palpable femoral pulses on these days. In 2 animals the thrombosis was bilateral: in one, bilateral loss of pulses on the fifth day, and, in the other, on the eighth and fifteenth days after operation.

In the 10 animals of this group in which freeze-dried vessels were used as grafts, 8, or 80 per cent, were excellent, and only 2 were considered poor. One of the latter had obliteration of the right and left femoral pulses on the fourteenth and twenty-seventh days, respectively, and the other, loss of the right femoral pulse on the ninth day following implantation of the graft.

Representative aortograms for this group of successful fresh and lyophilized homografted animals one year after insertion are shown in Fig. 3, *A* and *B*.

TABLE I. RESULTS OF RECONSTRUCTION OF AORTIC BIFURCATION IN 45 DOGS

	GROUP A		GROUP B	
	FRESH	LYOPHILIZED	FRESH	LYOPHILIZED
Number of animals	13	10	10	12
Average weight	19.6	20.8	23	21.5
Results:				
Excellent	6 (46%)	8 (80%)	6 (60%)	9 (75%)
Poor	7 (54%)	2 (20%)	4 (40%)	3 (25%)
Thrombosis	6	2	2	1 (Aorta)
Bilateral	2	1	-	-
Unilateral	4	1	2	-
Hemorrhage	1	-	1	-
Operative	-	-	-	1
Evisceration	-	-	-	1
Distemper	-	-	1	-

Group B.—Results following reconstruction of the bifurcation by this technique are likewise outlined in Table I. Of the 10 animals in which fresh grafts were used, 60 per cent were excellent. Of the 4 poor results, one animal died of distemper one month after operation and at autopsy its graft was patent. There was, however, considerable inflammatory reaction about the graft with numerous enlarged spongy lymph nodes. One dog was found dead on the fourth postoperative day with a large amount of blood clotted around the graft, but no evidence of disruption of suture lines or indication of the bleeding point. Thrombosis occurred in 2 dogs, and in both it was unilateral with a loss of the femoral pulse on the fourth and sixth days after operation.

As in Group A, the results with the lyophilized grafts were superior to the fresh. Of the 12 animals with freeze-dried grafts, 9, or 75 per cent, were excellent. Actually, the per cent of success in this group of animals might reasonably be considered higher if one were to eliminate the one animal dying ten days postoperatively following evisceration that occurred at night and was not discovered for many hours, and the one animal which received too much anesthetic agent from which it never awoke. The latter is the only operative death in the entire group of 45 animals.

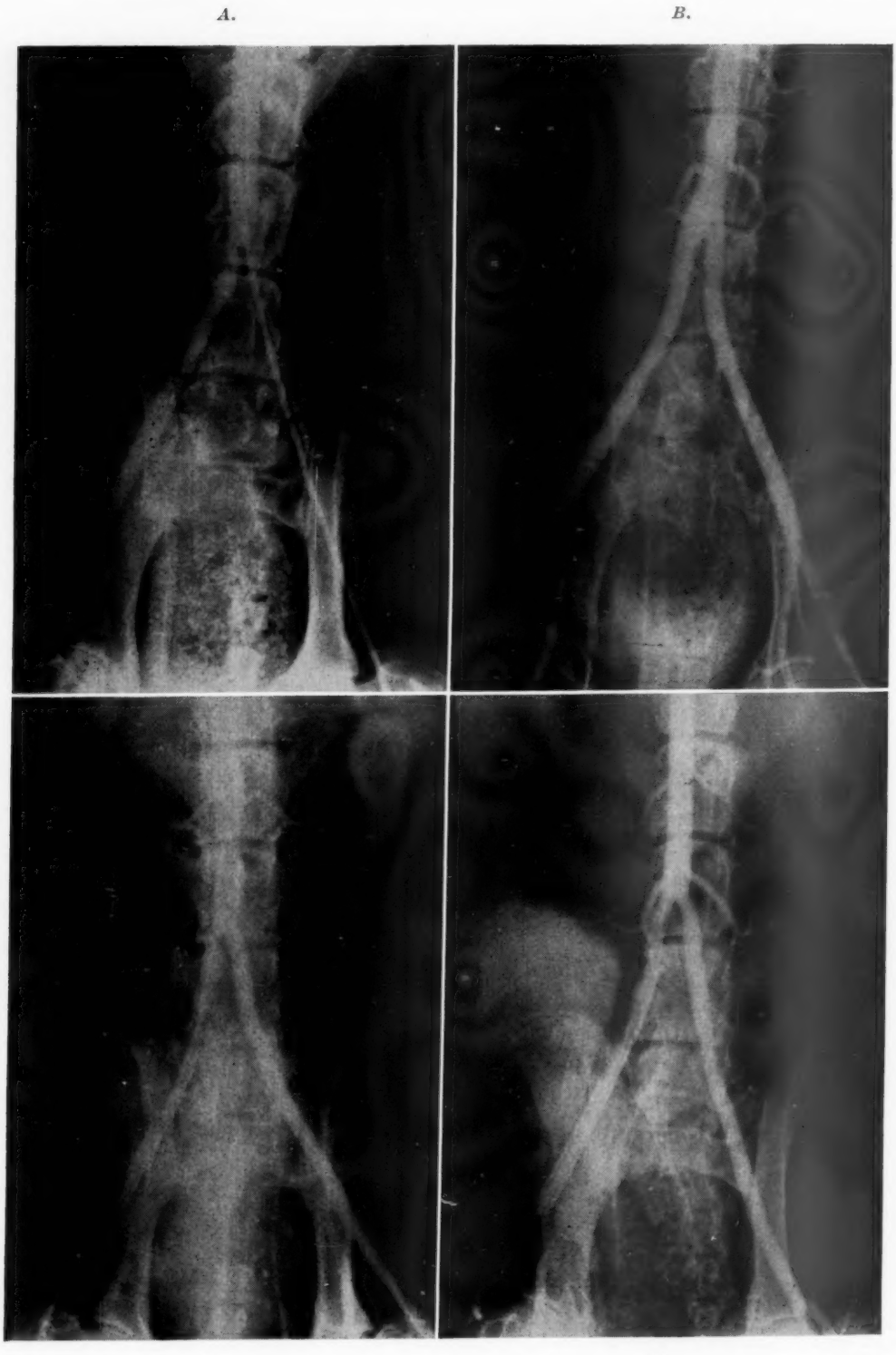

Fig. 3.—Aortograms one year after Group A type bifurcation reconstruction, fresh (*A*) and lyophilized (*B*); and Group B, end-to-side reconstruction, fresh (*C*) and lyophilized (*D*).

Fig. 4.

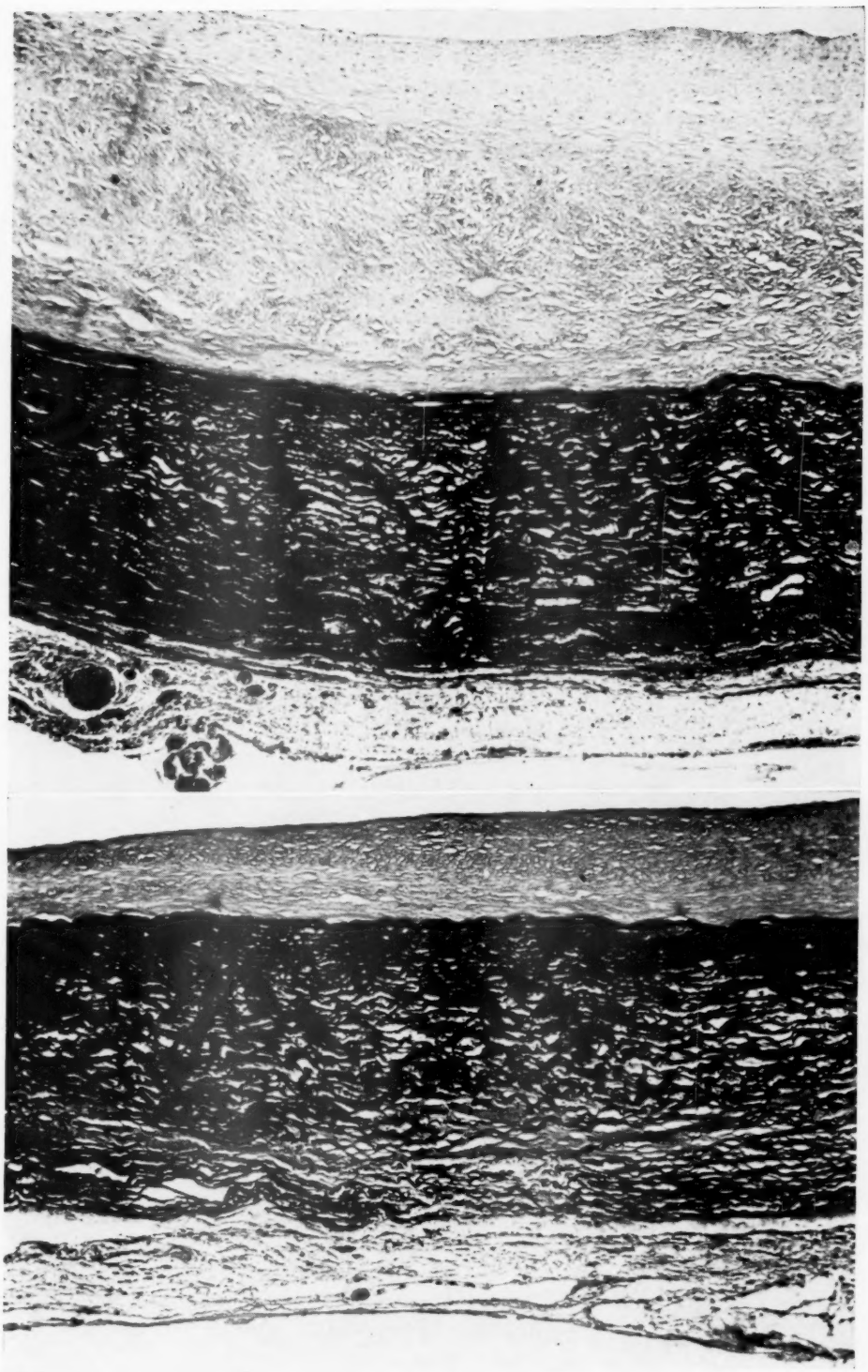

Fig. 5.

Fig. 4.—Lyophilized graft of eleven months' duration stained by the Verhoeff-Van Gieson elastic and connective tissue method revealing newly formed intima of connective tissue. The elastic fibers of the media are well preserved and the adventitia does not appear remarkable (×60).

Fig. 5.—Fresh graft of one year's duration revealing newly formed fibrous intima. The media is for the most part well preserved, although some separation of fibers by collagenous connective tissue bands is apparent (×60).

A third animal with poor results in this group was found dead twenty-four hours after operation. There was massive thrombosis of the graft-aortic anastomosis with clot extending into both renal arteries.

Representative aortograms of fresh and lyophilized grafts in this group twelve and eight months after insertion are shown in Fig. 3, *C* and *D*.

Blocks from the biopsied portions of the aortic grafts were fixed in 10 per cent neutral Formalin, dehydrated and infiltrated with paraffin in the usual manner. Sections from both fresh and lyophilized grafts were, for the most part, microscopically similar. The intimal surfaces of both were formed by fibrous connective tissue of varying thickness and cellularity derived from the reparative zones at the lines of anastomosis (Figs. 4 and 5). Areas of

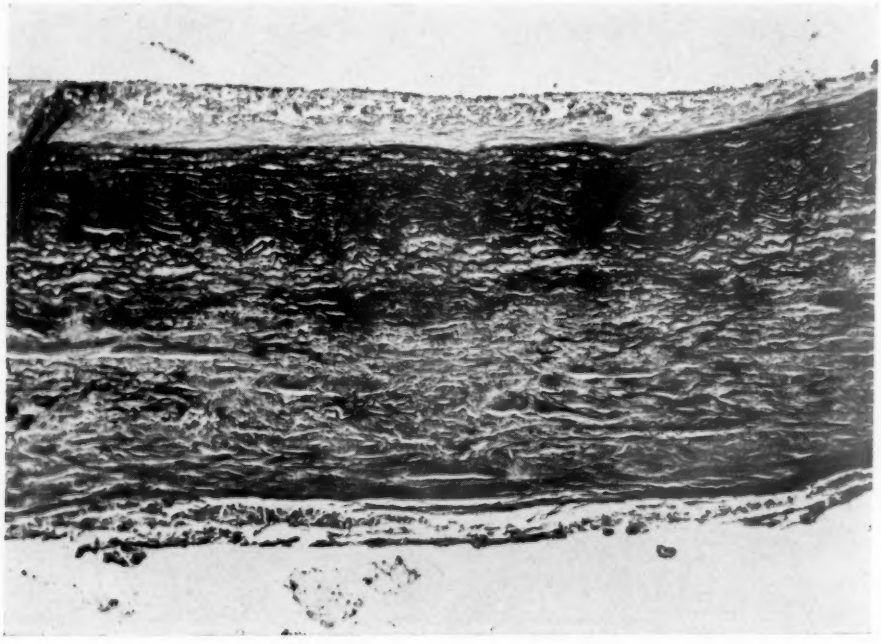

Fig. 6.—Fresh graft of one year's duration revealing fragmentation of media and lack of affinity of elastic fibers for the stain utilized in the Verhoeff technique as compared with Figs. 1 and 2. There is also medial and adventitial fibrosis (×60).

increased ground substance were apparent in this layer as evidenced by the metachromasia produced when sections were stained with 0.05 per cent thionine for one-half hour and differentiated in alcohol. Endothelial cells were not identified and thrombosis was not present. The elastic fibers of the media of both types of graft were, for the most part, well preserved and continuous. On occasion, however, they were discontinuous, fragmented, and they failed to stain distinctly with the iron hematoxylin of the Verhoeff elastic tissue technique (Fig. 6). This was most pronounced in the fresh grafts and was accompanied by medial sclerosis which also tended to separate the elastic tissue fibers in the medial zone. A few nuclei of smooth muscle cells in the media were observed only in the fresh grafts. The adventitia of both types was comprised of dense, relatively acellular collagen derived from the host vessel and reparative zones

at the lines of anastomosis. This layer was not unusually thick except in several fresh grafts when its width was greater than that of the media. Moderate adventitial vascularity was noted in both types of graft. Inflammatory reaction, except at the lines of anastomosis or calcification, was not observed.

Frozen sections of wet, Formalin-fixed tissue were stained with oil red O for the demonstration of lipids and the Schultz technique for cholesterol and cholesterol esters, as well as being examined by polarized light. Minimal, intimal, and medial deposits of nonbirefringent, extracellular, sudanophilic material were noted only rarely in one example of each type of graft. The Schultz reaction was negative.

DISCUSSION

In reviewing the autopsy records of the Children's Hospital in this Center, it was found that approximately 150 post-mortem examinations each year are performed. Of this number, about 10 per cent are on children over 10 years of age in whom the cause of death would not preclude the use of the aorta as a graft. It was felt that these certainly could be used to make short compilation homografts, as has been done successfully with small autogenous vessels by others, in order to bridge straight defects in the aorta. However, it was felt that their value for new bifurcations, using the technique described, required experimental evaluation. Particularly, it was important to evaluate the effect of the end thrust of blood directly against the suture line used in the fabrication of grafts in Group A and against the side of the graft as used in Group B. It was gratifying to find that no aneurysmal dilatation or rupture of the new bifurcation occurred even after one year, and that thrombosis of the new crotch occurred only once in 45 reconstructions. Furthermore, degenerative changes after one year were no different at this point than in the rest of the graft.

The morphologic appearance of the fresh and lyophilized grafts used in this study is similar to that observed in straight aortic grafts of comparable duration,[2, 9, 18, 22] although calcification was not encountered in any in which histologic examination had been performed. Except for the fragmentation, separation, and apparent degeneration of elastic fibers and fibrosis of the media of an occasional fresh graft after one year, this zone appears well preserved and not unlike that observed in grafts similarly prepared and of shorter duration. The infrequent occurrence of rare intimal and medial deposits of nonbirefringent, extracellular lipid which failed to react with the cholesterol method utilized is regarded as the result of nonspecific degenerative change and is not analogous to arteriosclerosis as encountered in the human being or experimental animal.[8]

The occurrence of thrombosis at the graft-ilaic anastomosis, either unilateral or bilateral, in 10 of the 45 animals, or in 13 of 90 such anastomoses (14 per cent) was of interest. Ten of the 13 thromboses (77 per cent) occurred in fresh homografts and only 3 (23 per cent) were in the lyophilized group.

In 10 of the 13, thrombosis was evident by the tenth postoperative day, and in the other 3 by the fourteenth, fifteenth, and twenty-seventh days, with no further loss of pulses during the protracted follow-up.

The outside diameter of the iliacs in this series of dogs, calculated from the measurement of the outside circumference of the intact distended vessel at the time of operation, averaged 6 mm. The outside diameter of the abdominal aorta distal to the renal arteries, determined in similar fashion, was 10 to 12 mm. Thus, the long-term results of this study (55 per cent excellent for all fresh grafts and 85 per cent excellent for all lyophilized grafts inserted, omitting the 3 dogs that died of evisceration, distemper, and anesthesia) may be compared with the findings of Miller and his colleagues[14] who performed femoral artery anastomoses in dogs using grafts with an outside luminal diameter of 3 to 4.5 mm. They reported 90 per cent function with fresh grafts and 83 per cent with preserved ones. Only 44 per cent of the fresh grafts in their series had defects, while 50 per cent of grafts preserved one to seven days and 75 per cent preserved eight to twenty-two days demonstrated abnormalities. The method of preservation was in a modified Tyrode's solution similar to that of Gross and associates.[10] Our per cent of satisfactory results for animals with fresh homografts of almost comparable sizes in place over six months was slightly lower than that of Miller's, 75 per cent to his 90 per cent. However, the satisfactory results of 90 per cent with lyophilized vessels are superior to his 83 per cent using vessels preserved in a liquid storage medium. Furthermore, no such degree of abnormality as observed by him in stored vessels was noticed with the lyophilized grafts.

Our findings that lyophilized homografts are superior to fresh homografts are similar to those reported by Pate and Sawyer,[15] whose results for these two types of grafts were 79 per cent and 48 per cent excellent, respectively, when implanted into the abdominal aorta as straight segments.

SUMMARY AND CONCLUSIONS

To evaluate the use of aortas removed at pediatric necropsy for bifurcation reconstruction in the adult, aortas from young dogs were fashioned into grafts and were used to replace the aorta in adult animals. The two types of reconstruction, end-to-side and "Y," were found to be equally satisfactory, and might well be used in human beings where there is disparity between the size of the host and the donor aorta. Since fresh and lyophilized homografts were inserted in equal numbers in both groups, it was possible to compare results on the basis of the type of graft used. Our findings were similar to others in that better results were obtained using lyophilized grafts. In animals followed for as long as one year, excellent results were obtained in 85 per cent of the former and in 55 per cent of the latter.

The microscopic degenerative findings of grafts in place for one year were comparable to those observed in straight aortic grafts.

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AORTIC EMBOLECTOMY

A Critical Evaluation of Eleven Consecutive Cases

Clarence J. Schein, M.D., Paul W. Hoffert, M.D., and
Elliott S. Hurwitt, M.D., New York, N. Y.

(From the Surgical Division, the Montefiore Hospital)

A SADDLE embolus represents a peripheral catastrophic event in the course of certain types of heart disease. Emboli to the aortic bifurcation allegedly constitute between 9 and 12 per cent of all peripheral emboli[5, 14] and usually have their source in a rheumatic auricular appendage or on the wall of an infarcted myocardium. Autochthonous thrombosis and paradoxical emboli are far less common. The high mortality rate, ranging between 75 to 100 per cent,[16] constitutes a continuing surgical challenge. This report is concerned with eleven consecutive operative cases treated at the Montefiore Hospital by eight surgeons over a four-year period, between July, 1951, and May, 1955.

There were nine women and two men in this series. Their ages varied from 42 to 82 years, with seven of the patients falling in the 50- to 69-year-old group. Two of the patients were 42 years of age, and two were 80 or over. Five of the patients had rheumatic heart disease and were in chronic auricular fibrillation; three of them had experienced previous emboli. Three of the six patients with arteriosclerotic heart disease had significant auricular arrhythmias, but no previous embolic episodes. Seven of the eleven patients were in auricular fibrillation.

In ten of the patients, the onset of symptoms was sudden and dramatic; no history was available in the case detected four hours after cardiac surgery. In this instance, the nature of the postoperative catastrophe was discovered as the result of a postoperative check of peripheral pulsations by the resident staff. This patient survived, and is alive and well four years postoperatively. The prompt recognition of the embolism, and the rapid institution of definitive therapy contributed to the favorable outcome in this case.

In five of the patients, the sudden presenting symptom was severe pain in one or both lower extremities. In the remaining five, there was associated severe pain in the lower back or abdomen. The initial confusion in diagnosis of patients who first present with lower extremity paralysis has been noted many times as a source of delay in instituting prompt therapy.[3] On physical examination, all patients exhibited coldness and mottled cyanosis of the lower extremities with varying degrees of mottling of the anterior abdominal wall, as well as absent femoral pulsations, with marked to total impairment of motor power and sensation.

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Operative intervention was carried out at varying intervals following the onset of symptoms. The shortest time interval was three hours and the longest twenty-four hours after the onset. It is generally agreed that one can anticipate success in the management of these cases only if early surgical intervention is employed.[13] Of the eleven patients, three (27 per cent) who survived were operated upon within four, six, and six and one-half hours; they all left the hospital with normal limbs. That this is not the only factor is shown by the observation that of the eight patients who did not survive, four were operated upon five and one-half hours or less after the onset of symptoms.

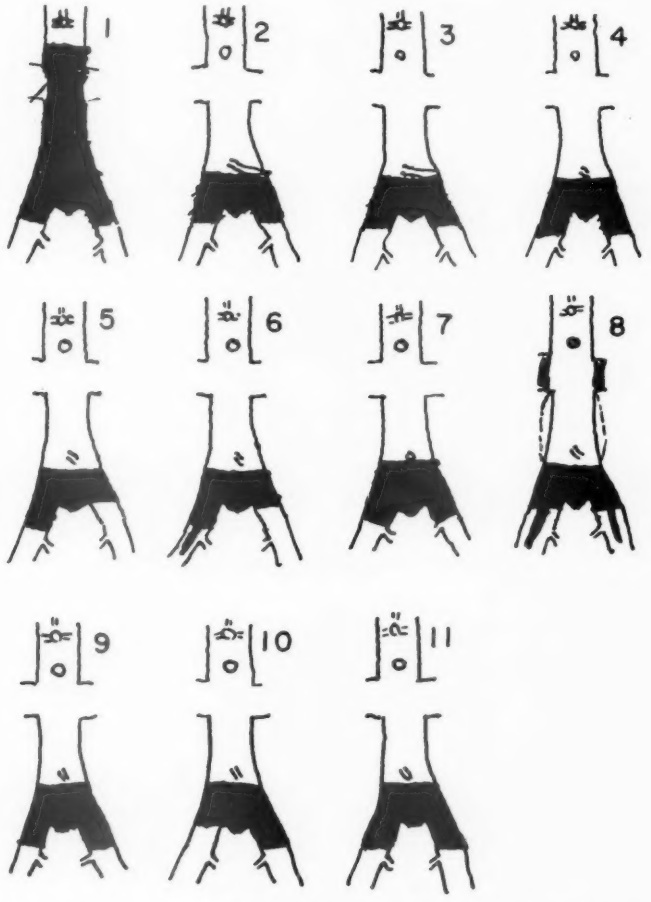

Fig. 1.—The extent of each embolus is diagrammatically illustrated.

In all instances, a transperitoneal approach was employed. Spinal anesthesia was used in eight instances, general-endotracheal in two instances, and intravenous Pentothal in one instance. The extent of the embolus encountered in each instance is diagrammed in Fig. 1. In four patients, cardiac arrest occurred on the operating table. Only one of these patients was temporarily resuscitated. This 53-year-old woman required re-exploration twelve

TABLE I. SUMMARY OF CASES

CASES	NAME	AGE	SEX	ETIOLOGY	ONSET	HOURS TO SURGERY	PREVIOUS EMBOLI	CARDIAC RHYTHM	COMPLICATIONS UNDER ANESTHESIA	ADEQUACY OF CLOT REMOVAL	ANTICOAGULANTS POSTOP.	RESULT
1	B. B.	42	F	R.H.D.	Pain in legs	3	Yes	A.F.	0	Complete	Heparin I.V.	Died 8 hr. postop.; mesenteric and renal emboli
2	M. F.	42	F	R.H.D.	Under anesthesia	4	Yes	A.F.	0	Complete	Heparin I.V.	Alive 4 years postop.
3	B. G.	50	F	R.H.D.	Pain in legs	6	Yes	A.F.	0	Complete	Heparin I.V.	Alive 4 years postop.
4	J.C.	52	F	R.H.D.	Pain in legs	5½	0	A.F.	Cardiac arrest	Aorta not explored	0	Died on table
5	L. H.	53	F	R.H.D.	Pain in legs	6½	0	A.F.	0	Complete	Heparin Dicumarol	Died 16 months postop. of carcinoma of pancreas; aorta normal at autopsy
6	S. J.	53	F	A.S.	Paralysis; pain in back	12	0	R.S.R.	Cardiac arrest	Inadequate	0	Died on table
7	L. M.	59	F	A.S.	Pain in back and legs	4	0	R.S.R.	0	Inadequate	?	Died 9 days postop.; gangrene of both legs
8	C. P.	65	M	A.S.	Pain in back and legs	18	0	R.S.R.	0	Aorta not explored	0	Died immediately after abdomen entered
9	J. P.	69	F	A.S.	Pain in back and legs	3	0	A. flutter	Cardiac arrest	Complete	0	Died; rupture of ventricle during cardiac massage; mesenteric and renal infarcts; aorta clean
10	A. C.	80	F	A.S.	Pain in abdomen and legs	7	0	A.F.	Cardiac arrest	Incomplete	0	Died on table
11	G. R.	82	M	A.S.	Pain in legs	24	0	A.F.	0	Complete	?	Died 10 hours postop.

A.F., auricular fibrillation; R.S.R., regular sinus rhythm.

hours later because of persistent absence of a left femoral pulsation. A retrograde femoral approach was employed under local anesthesia, and the patient expired on the operating table. The heart of patient No. 9 was ruptured during cardiac massage.[6]

Of the eleven patients, five had aortas described grossly as markedly sclerotic; in four instances, the sclerosis was of moderate degree; in one instance, the aorta appeared grossly normal; and in another no mention was made of the condition of the aorta from the standpoint of sclerosis. Of the three patients who survived, one had a normal aortic wall, one had moderate sclerosis, and in the third no mention was made of the condition of the aortic wall.

A brief description of the three survivors follows.

CASE 2.—This 42-year-old woman had a mitral commissurotomy on July 30, 1951; the primary indication for operation was previous embolization. During the operative procedure,* a thrombus was palpated in the left auricular appendage. This broke off during the operative manipulation. Four hours postoperatively, absence of femoral pulsations was noted, associated with early ischemic changes in the legs. Immediate satisfactory embolectomy was performed. This patient made a complete recovery and has normal limb function at the time this report is written.[2]

CASE 3.—This 50-year-old white woman was admitted† on July 27, 1951, six hours after the onset of lower extremity pain. She had a long-standing history of mitral stenosis and auricular fibrillation. Embolectomy was successfully performed.‡ Her postoperative course was complicated by wound evisceration. She remains alive with complete function of the lower extremities.§

CASE 5.—This 53-year-old white woman was admitted‖ with a history of mitral stenosis and two cerebral emboli. A mitral commissurotomy was performed.¶ on Jan. 15, 1953. Eight weeks postcommissurotomy, she presented with discoloration and pain of both lower extremities. A successful embolectomy was performed,¶ and the patient made an uneventful recovery with complete lower limb function. She died sixteen months later of a carcinoma of the tail of the pancreas with metastases. At necropsy, there were mural thrombi in both auricular appendages with a free thrombus in the left atrium occluding the mitral orifice. The aortotomy incision was well healed and unremarkable.[4]

In critically reviewing these cases, the following factors appear significant in the survivors:

A. All three had rheumatic heart disease as the underlying pathology. They were among the younger patients in the series (42, 50, and 53 years) and exhibited minimal aortic sclerosis. The survival is, of course, primarily dependent upon the nature of the cardiac lesion.

B. Although it is not the only significant factor, the interval between onset of symptoms and definitive surgery is of major importance in determining the outcome. Early operation prevents secondary thrombosis of the distal radicals. Thus, in the three survivors, operative intervention was undertaken within six and one-half hours.

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*By Dr. A. E. Bloomberg.
†Medical service of Dr. Harry Gross.
‡By Dr. Ralph Deterling.
§A detailed description of this case will be included in a report in preparation by Deterling and co-workers.
‖Medical service of Dr. Jacob Grossman.
¶By Dr. A. Kantrowitz.

C. In the three survivors the clot had been successfully evacuated. This is in contrast with three cases where incomplete evacuation, inadequate blood flow following extraction of clot, and rapid reformation of thrombus were present or "threatening."

D. The location and extent of the clot appeared to have some bearing on the outcome of the case. Thus, if the extent of the clots in the three survivors is noted (Fig. 1, Cases 2, 3, and 5), it will be seen that in these three instances the clot was of limited extent, and did not propagate for any appreciable distance proximally toward the renal vessels, or distally into the iliac vessels. This is in marked contrast with other cases where extensive clot formation was present at the time of surgery in association with rather marked intrinsic arterial sclerosis, necessitating endarterectomy as part of the recanalization procedure. That the size of the clot encountered is not simply a function of the time interval that has elapsed before definitive surgery is undertaken is well illustrated by Case 1. In this instance only three hours elapsed before surgery was performed, yet the extent of the clot was very marked, involving the renal and inferior mesenteric vessels. In the presence of such a massive clot, even immediate surgical intervention may be of no avail, since there may be associated showers of emboli to multiple arteries.

E. The presence of pain in the back or lower abdomen in addition to pain in the lower extremities was of serious prognostic import. Thus, of the three survivors, two complained only of pain in the lower extremities. The third had no subjective complaints since she was still under the influence of the anesthesia (Case 4). Of the eight patients who died, five had definite complaints of pain referable to the low back or lower abdomen in addition to the lower extremities.

F. The appearance of cardiac arrest during operation led to a fatal outcome on the operating table in the four cases in which it occurred. Of the four cases of cardiac arrest, three patients had arteriosclerotic heart disease and only one had a definite history of rheumatic heart disease. The occurrence of cardiac arrest thus accounts for 50 per cent of the fatal cases.

With reference to Case 5, several authors[1, 10] have recommended left auricular appendectomy in patients with auricular fibrillation to prevent further embolization. This patient had no further emboli for sixteen months even though she continued to fibrillate. In this case, the stasis of blood in the left atrium had been relieved by the mitral commissurotomy and the auricular appendage had been ligated at its origin at that time. It is interesting to note, however, that the embolization occurred three months following commissurotomy. This suggests that a more complete auricular appendectomy than is usually performed during a valvulotomy may be necessary in order to avoid late embolization.

The occurrence of hematuria is an interesting finding in several of these patients. In this series, hematuria was noted grossly in three patients (Cases 1, 8, and 9), all of whom died. In two instances, the hematuria was easily

explained at post-mortem examination by the presence of multiple renal infarcts. In one patient (Case 1), the kidneys were completely negative at necropsy. The urinary bladder was also grossly unremarkable, and the etiology of the hematuria was never established. It is suggested that the acute ischemia of the bladder caused by the saddle embolus is etiologically related to the gross hematuria.

Plan of Management.—The key to effective therapy is prompt and accurate diagnosis. The majority of patients with a saddle embolus of the aorta will exhibit severe pain in the lower extremities and/or lower abdominal or back pain. In some instances, the involvement of the lower extremities may manifest itself solely as numbness or paralysis. Once the diagnosis is made, plans should be made to institute surgery as promptly as possible. The operative procedure aims at restoring the aortic pathway. The cardiac danger in the patient with mitral stenosis is another problem. A prompt and technically adequate embolectomy may be completely frustrated by the severity of the valvular damage, with failure to demonstrate improved circulation clinically, despite a patent aorta and distal arteries at necropsy.[15] Ancillary medical measures may be necessary, such as restoration or maintenance of cardiac compensation, analgesics, and oxygen to aid pulmonary function.

Spinal anesthesia is the anesthetic of choice in most of these cases because of the excellent muscular relaxation obtained, and the contracted state of the small bowel. A left rectus splitting incision centered at the umbilicus affords excellent exposure of the region of the aortic bifurcation. After the abdomen is entered, the patient is placed in the Trendelenburg position. The rubber bag described by Lahey,[8] into which the entire small intestine may be eviscerated, serves admirably to gain good exposure. A longitudinal incision is made in the posterior parietal peritoneum overlying the terminal aorta, and by blunt dissection the region of the bifurcation and the first 2 inches of each common iliac artery are exposed. Umbilical tapes are placed doubly encircling the aorta proximally and each common iliac vessel distally. By palpation, the exact location of the thrombus is determined, and an arteriotomy incision is made longitudinally through the anterior wall of the aorta overlying the central portion of the contained thrombus. The incision is usually 2 to 4 cm. in length. As the incision is placed, assistants snug up on the umbilical tapes gently to prevent a sudden excessive loss of blood through the opening in the vessel. As the opening is made in the aortic wall, the thrombus extrudes itself partially through the incision. Then, by digital compression, with the distal umbilical tapes held taut to prevent the propulsion of a possible small segment of thrombus, the distal portion of the thrombus is milked upward and extruded through the aortic incision. This is repeated on the other side, thus freeing the thrombus from both common iliac vessels. Now the distal umbilical tapes are relaxed on the iliac vessels, and if all the thrombus has been milked out, free "back" bleeding occurs through the aortotomy incision. This indicates patency of the anastomotic channels distal to the site of occlusion.

At this time, the distal umbilical tapes on both common iliacs are again pulled taut. The proximal umbilical tape on the aorta is now relaxed and as the arterial pressure head mounts proximal to the thrombus, the clot may be extruded through the aortotomy opening. If this is ineffective, the clot may be extruded by a gentle digital milking action from above. Occasionally, digital milking of the clot may not completely deliver a thrombus. The judicious use of various sizes of gall bladder and common duct stone forceps to grasp and extract the clot is of considerable value. Brisk irrigation through the arteriotomy incision with normal saline solution followed by suction may also help loosen a clot for extraction.

The proximal and distal tapes are alternately loosened and then tightened to demonstrate free bleeding proximally and distally. The aortotomy is closed with either a continuous everting or interrupted everting mattress suture of 5-0 braided silk on an Atraumatic arterial needle. Following closure of the aorta, 50 mg. of heparin in 5 c.c. of normal saline solution is injected into the lumen of the aorta proximal to the aortotomy incision and maintained in the local area for one minute by digital compression of the aorta both above and below the aortotomy site.

After closure of the aortotomy incision, reformation of thrombus at this site may occur. It is important, therefore, to continue observation of this area for at least twenty minutes following closure of the aortic incision. If thrombus does form, it is necessary to reopen the aortotomy and remove the fresh clot. The posterior parietal peritoneum need not be sutured over the aorta, and the wound is closed in layers without drainage.[9]

There is a sharp difference of opinion in the literature concerning the use of postoperative anticoagulation therapy. Madden[12] is opposed to the use of postoperative anticoagulants because of the high incidence of complications due to hemorrhage. Lord and Burke,[11] on the other hand, recommended routine use of anticoagulation therapy postoperatively. It is their belief that the heparin reverses sludge formation and prevents thrombosis in the small arteries of the distal portions of the lower extremities. Moreover, they feel that immediate heparinization followed by long-term Dicumarol therapy will prevent subsequent emboli which may lead to the patient's death. Another of their indications for anticoagulants is associated venous thrombosis of the legs.

In this series, four of the eleven patients had postoperative anticoagulant therapy in the form of intravenous heparin and subsequent Dicumarol; all three survivors were so treated. On the basis of this experience, postoperative anticoagulation would appear to offer certain advantages. The use of reflex heat to produce peripheral vasodilatation, and the careful wrapping of the extremities in cotton wadding to prevent skin trauma are additional aids.

The long-term management of such a patient is a medical one, aimed at the underlying cause of the embolic phenomena. Where the source of the embolus is a thrombosed left auricular appendage associated with mitral stenosis and auricular fibrillation, the patient should seriously be considered for early mitral commissurotomy and ablation of the auricular appendage, in order to

relieve the stasis of blood in the left atrium and to eliminate one source of thrombi. This plan of management was successfully carried out in 1952 in a desperately ill 50-year-old woman in severe congestive failure, who experienced a classical saddle embolism which migrated to the left iliac artery while preparations for operation were being made. The patient left the hospital, walking, sixty-one days after iliofemoral embolectomy and fifteen days after cardiac surgery; her improvement has been maintained, to date, for almost three years.[7] If the source of embolization was a mural thrombus secondary to myocardial infarction, long-term anticoagulant therapy may be indicated.

The prognosis for an individual patient may be estimated from the history and the findings at the time of surgery. If the history is longer than six to eight hours, and is accompanied by back pain in a patient with arteriosclerotic heart disease, the prognosis is poor. Prompt surgery in the rheumatic patient without back pain is a more favorable combination. Incomplete recanalization due to accompanying primary arterial disease, or an unfavorably extensive clot almost certainly precludes a favorable result as far as survival or limb salvage are concerned. Cardiac arrest on the operating table was invariably fatal.

The poor surgical results are related to the poor prognosis for the basic cardiovascular condition. Because the operation can, at best, result only in limb salvage without influencing the etiology, there are certain patients who are best managed by nonoperative methods. Where the status of the limb or life is already beyond salvage, surgery is pointless. If the aortic occlusion is one of many simultaneous or consecutive emboli that also involve the cerebral or mesenteric vessels resulting in a premorbid general condition, surgery has little to offer. From a review of the published experience, as well as the data detailed here, aortic embolectomy after nine hours is doomed to almost certain failure. Under such circumstances conservative measures consisting of paravertebral sympathetic block, anticoagulants, protective bandaging of the limbs, reflex hyperemia, and the use of vasodilator drugs, constitute the treatment of choice. The vast majority of patients who have to be treated conservatively will not survive.

SUMMARY

1. Eleven consecutive operative cases of saddle embolus of the aorta encountered over a four-year period are analyzed.

2. The survival rate among the 11 patients was 27 per cent (3 survivals).

3. The factors influencing prognosis are discussed. Specific contraindication to surgery are a moribund patient, nonsalvagable limbs, occlusion of more than nine hours' duration, and the coexistence of cerebral or mesenteric emboli. An aortic embolectomy should be attempted in all other patients.

4. A method of management of saddle embolus is presented.

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ANTIBODY PRODUCTION AFTER CERTAIN FORMS OF TRAUMA

RONALD A. MALT, M.D., AND OLIVER COPE, M.D., BOSTON, MASS.

(From the Surgical Research Laboratories of the Harvard Medical School at the Massachusetts General Hospital)

BACTERIA persist in the burn wound and for reasons poorly understood. They multiply on the open wound grossly free of necrotic tissue, and on the inner surfaces of superficially sterile eschars.[26] Their unsuppressed growth suggests either a weakness in host defense, perhaps impairment of antibody production, or the development of a new virulence made possible by the condition of the wound. Clinical evidence has already been presented pointing to a depletion of specific antibodies in patients soon after a burn and a correlation between recovery and rise in antibody titer.[25]

From a theoretical point of view, too, there is certainly ample reason to expect antibody fabrication to be depressed during post-traumatic states in general. Some of the pertinent evidence that needs to be considered in this respect is cited below:

That high levels of cortisone and corticotropin inhibit immune-body formation[16] and depress levels of antibody in the serum after immunization is well established.[12] (Older work purporting to show heightened antibody formation after administration of adrenal cortical extracts[3] is probably invalid, but it is not necessarily so).[8]

Cannon[2] has demonstrated both chemically and immunologically a low level of antibody production in the malnourished patient. Poor diet also may contribute to low levels of gamma globulin[24] and to partial suppression of antibody formation,[33] although these conclusions seem to be somewhat dependent upon the population studied.[38] In fact, the studies of Balch,[1] and of Havens and associates[19] have failed to demonstrate any difference respectively in the pattern of secondary or primary immunological response to diphtheria toxoid in depleted, malnourished patients.

Fever alone has often been shown to cause a varying impairment of antibody response in experimental animals,[10, 17] and certainly the once-supposed increase in anamnestic antibody from a fever unrelated to the primary immunizing agent has been discredited.[23]

Through the mediation of ill-defined changes in the nervous system, trauma per se has been incriminated as a cause of hypogammaglobulinemia.[18]

Even administration of antibiotics has been shown to inhibit formation of antibodies against a single antigen,[33] but this work has not yet been confirmed.

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The investigations of Fox and Lowbury[13, 14] can be interpreted both as demonstrating and as denying a relationship between burn trauma and the elaboration of protective antibodies. On the one hand, Fox and Lowbury found in burned patients a serial rise in antipseudomonal agglutinins as time post-burn increased, and evidence that antibody does afford some protection in burned rabbits. These findings are compatible with those of Langohr, Owen, and Cope[25] regarding the staphylococcus. The paradox comes in the English workers' discovery that there is an association of an elevated antibacterial titer with graft failure, quite the reverse of what Langohr and his colleagues saw.

With knowledge of the conflicting interpretations derived from many experiments, we set out to determine by a sensitive technique whether certain forms of trauma that imitate facets of the totality of the burn wound influence antibody response. Most experimental trauma was found to have no significant effect, but a fracture of the tibia unexpectedly enhanced antibody production.

METHOD OF STUDY

Classical immunochemical methods of quantitating antibody are laborious and expensive. Less complex methods such as serial dilution and titration are too crude to show any but large changes in amounts of immune-bodies present. A technique developed in recent years by Dixon and his co-workers,[6] however, is admirably suited to the purpose of this experiment.

The rationale of this novel method lies in the well-known observation that the rate of disappearance of injected antigen is a function of antibody formation. Easy quantitation of antigen is achieved by coupling the pure protein with I^{131} so that ordinary quantitative radiochemical determinations may be made. Gentle coupling procedures do not alter the immunological specificity of the molecule.

The I^{131}-protein bond is stable in vitro[9] and in vivo.[22] Free I^{131} liberated within the body, principally by catabolism of antigen-antibody complex in the reticuloendothelial system,[6] is rapidly excreted without incorporation into the organism's own protein as long as the tissues have been saturated with stable iodide by prefeeding.[5] In short, the I^{131}-protein label "... is the best-studied, and from many points of view the most satisfactory label so far utilized in immunological studies."[4]

Homologous protein must serve as a control on nonspecific protein turnover time and on dilution-concentration factors in any experiment. Homologous gamma globulin for iodination is readily prepared from pooled sera of the designated species of animal.[29] Commercial rabbit antipneumococcal serum* can be used as a source of crude rabbit gamma globulin. Bovine gamma globulin is the antigen of choice in most experiments. It is readily obtained,† and it is highly antigenic.

Iodination may be carried out in the laboratory,[27] or a commercially iodinated globulin of good quality may be purchased.‡

Calculation of the percentage of radioactivity remaining in the circulation at any time is possible by comparing the number of disintegrations present in an aliquot of blood with the number theoretically present in the same volume immediately after injection and thorough mixing of the radiochemical. The 100 per cent mixing value is computed by assuming a blood volume based on body weight and dividing the number of counts infused by the blood volume expressed in milliliters. Obviously, it makes no difference what volume is assumed, but because a volume of 5.1 per cent of body weight has been employed by others,[35] it was also employed in our experiments.

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*Dr. David Gitlin, Children's Medical Center, Boston, contributed the rabbit gamma globulin used in our pilot experiments, and Mr. H. D. Piersma of Lederle Laboratories, Pearl River, N.Y. donated supplies of antipneumococcal sera.

†Armour Laboratories, Chicago, Illinois.

‡Abbott Laboratories, North Chicago, Illinois.

It is not necessary to separate plasma protein from the serum before counting since the rate of loss of radioactivity from the serum parallels the loss of precipitable antigen.[28] Use of the scintillation counter, besides adding precision to the data through the instrument's rapid counting speed, permits samples to be counted as whole blood without consideration of self-absorption.

Semilogarithmic graphs are plotted with the percentage of antigen remaining in the circulation expressed as a function of time for ease in comparing degradation rates of different animals. Typical curves determined following the administration of radio-iodinated bovine gamma globulin (BGG) and of radio-iodinated rabbit gamma globulin (RGG) to immunologically virgin rabbits are shown in Figs. 1 and 2. Notice that until the fourth day the plots are similar; during this time equilibrium is occurring, and both proteins are being metabolized without interference of any immune mechanism.[15] The strikingly increased disappearance rate of BGG after the fourth day is caused by the appearance of antibody[6] and the formation of antigen-antibody complex.[34] Earlier appearance of antibody is manifested by an earlier inflection; the converse is also true.

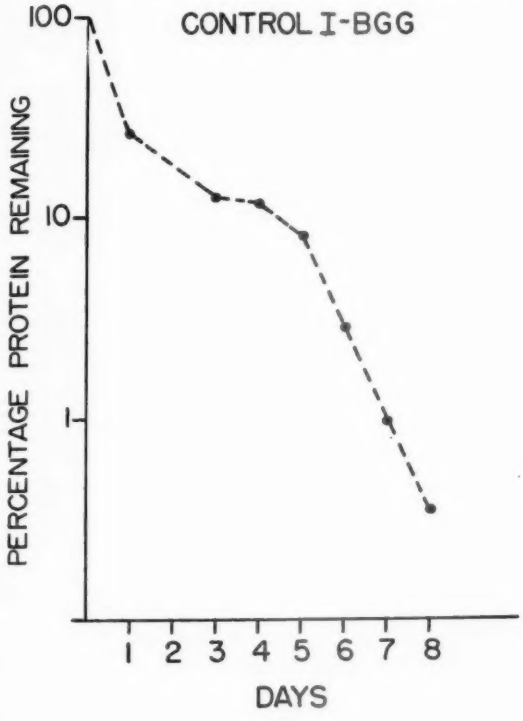


Fig. 1.

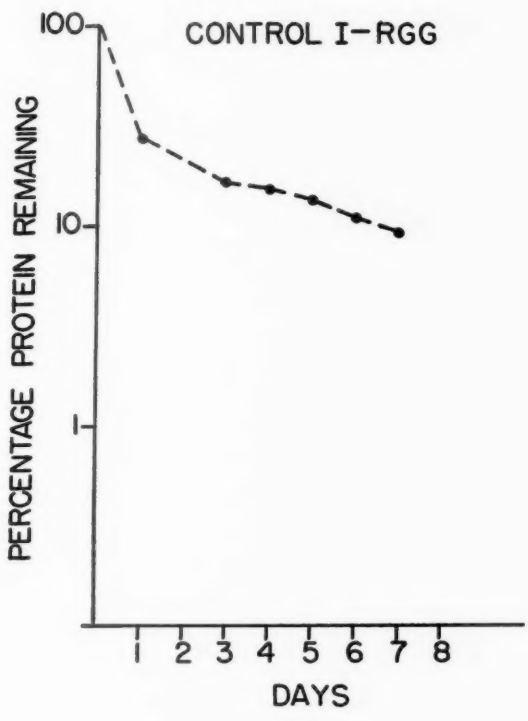


Fig. 2.

Figs. 1 and 2.—These represent degradation patterns of I^{131} -bovine gamma globulin (BGG) and I^{131} -rabbit gamma globulin (RGG) in untraumatized animals.

In the experiments reported below, groups of rabbits were subjected to various forms of trauma to help determine whether specific aspects of traumatic experience particularly related to the burn wound might influence the antibody response. The open wound was to serve as a minimally contaminated disruption of the skin with slight fluid shifts and endocrine alterations. A long stay in the cold room was supposed to stimulate the adrenal cortices and yet cause no tissue damage at all. (Rabbits are very skillful in protecting their tissues from frost if they are permitted to do so, as they were in this situation.) The fractured tibiae were designated as a form of severe trauma without infection or loss of surface integrity, for they were to be closed fractures. Finally, the burn was to be the most severe insult, with actual loss of skin and presence of infection, fluid changes, and hormonal reactions to injury.

EXPERIMENT

Two shipments of female albino New Zealand-strain rabbits were received. Each shipment constituted a testing population, and the data obtained from each is listed separately in Tables I and II respectively. The 32 animals in

TABLE I. MEAN VALUES—PERCENTAGE OF INJECTED ANTIGEN REMAINING IN THE CIRCULATION

	BOVINE GAMMA GLOBULIN				RABBIT GAMMA GLOBULIN			
	CONTROL	FRACTURE	WOUND	COLD	CONTROL	FRACTURE	WOUND	COLD
No. animals	4	4	4	4	3	5	3	5
Day 1	26.09	37.29	25.92	30.26	27.22	24.71	22.08	29.35
2	--	--	--	--	--	--	--	--
3	13.33	18.01	14.42	17.78	16.39	13.58	14.15	19.87
4	11.74	11.60	11.25	13.85	15.36	10.68	12.47	16.50
5	8.07	3.92	6.90	11.01	13.51	8.33	9.86	14.89
6	2.83	0.50	2.75	4.78	10.95	6.87	8.15	11.31
7	0.98	0.15	0.52	2.39	9.29	5.68	6.96	9.84
8	0.35	0.11	0.14	0.68	--	--	--	--

TABLE II. MEAN VALUES—PERCENTAGE OF INJECTED ANTIGEN REMAINING IN THE CIRCULATION

	BOVINE GAMMA GLOBULIN		RABBIT GAMMA GLOBULIN	
	CONTROL	BURN	CONTROL	BURN
No. of animals	4	4	4	4
Day 1	--	--	--	--
2	36.81	32.22	23.43	22.93
3	28.11	24.83	19.66	19.52
4	20.31	17.68	15.22	16.34
5	10.33	10.89	12.51	13.69
6	3.21	3.21	10.47	11.26
7	1.08	1.08	8.54	9.39
8	0.36	0.30	7.06	7.95

the first shipment varied in weight from 1.8 to 2.8 kg. (mean 2.34 kg.), and the 16 rabbits in the second ranged from 2.48 to 3.23 kg. (mean 2.88 kg.). Animals within each shipment were assigned to the various treatment and control groups by a random process. Two animals ultimately destined to receive the same treatment but different globulins were randomly paired in each cage.

For the week before the experiments, about 6.0 mg. of potassium iodide in solution was placed daily in the water bottle of each cage. The diet consisted of Purina rabbit chow with twice weekly additions of greens and carrots.

Anesthesia was induced in every rabbit with 0.8 to 1.0 ml. of intravenously injected sodium pentobarbital (Nembutal). Within one hour after induction the animals were injected with known doses of 100-200 μc of radio-iodinated BGG* or RGG* containing 10 to 20 mg. of protein and then were subjected to the various treatments. BGG used in these experiments was represented as being immunologically pure; RGG, which we prepared, was from 85-95 per cent pure by boundary electrophoresis, with β-2 globulin the contaminant.

The control animals were not further manipulated.

Ten centimeter long wounds were inflicted upon one group of animals by a single stroke of the scapel through the shaved, antiseptically prepared skin

*Iodinated by Abbott Laboratories, Chicago, Illinois.

of the back to a depth part of the way through the first muscle group encountered. Bleeding was minimal and was staunched by pressure; the wounds were not dressed. Inspection at daily intervals showed only the slightest sepsis.

Each rabbit placed in the cold room was housed in an individual cage without food or water during her sojourn there. The animals were subjected to −18° C. for twenty-two hours. No tissue damage was demonstrable at any time.

The right tibia of each rabbit in the appropriate series was fractured at its mid-point by being snapped between the experimenter's hands. All fractures were originally closed, but as no splint was applied, they all became open wounds. Exudate and infection were minimal.

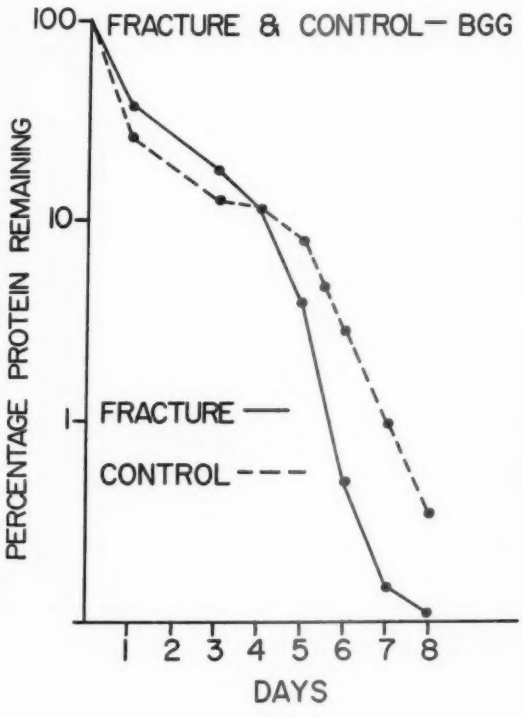


Fig. 3.

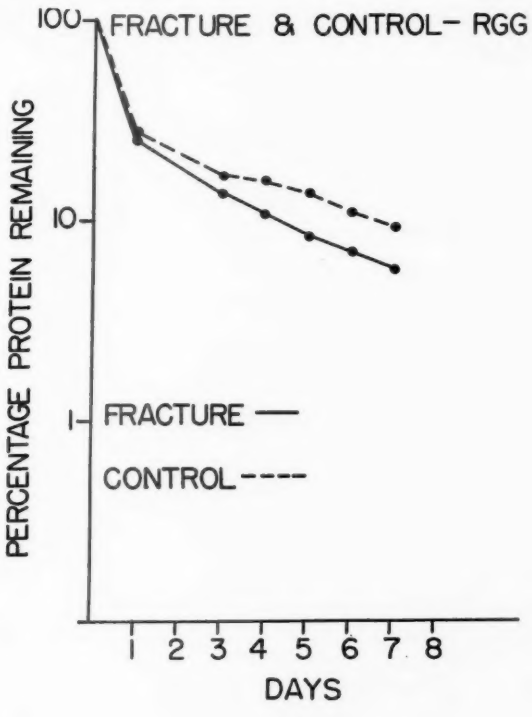


Fig. 4.

Figs. 3 to 8.—These show the handling of BGG and RGG by traumatized animals in comparison with their controls.

Burns were administered by a plate of steel heated to a dull red and applied for ten seconds to a region of clipped hindquarter skin comprising about 10 to 15 per cent of the total body area. Inspection of all burns showed that they were indeed full thickness and grossly infected. The rabbits themselves did not seem to be too incapacitated by their burns.

After treatment all animals were then returned to their cages with access to food and water.

Except for the first or second day following injection of the proper globulin, blood was taken daily from the marginal ear veins of each rabbit by

Fig. 5.

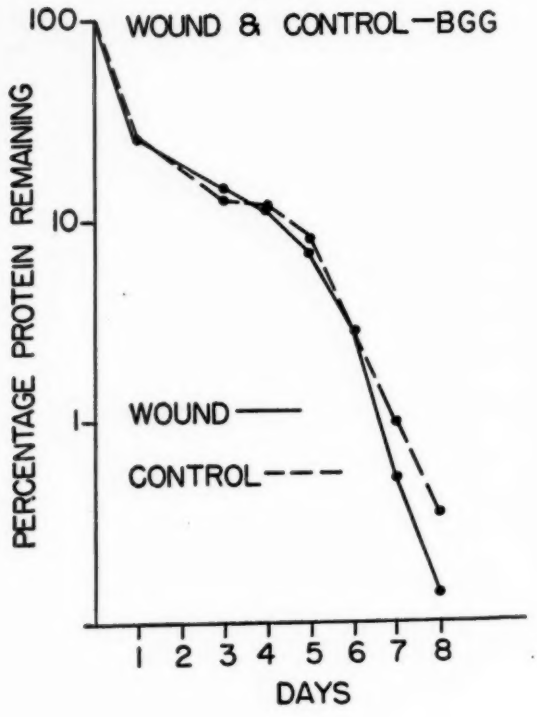
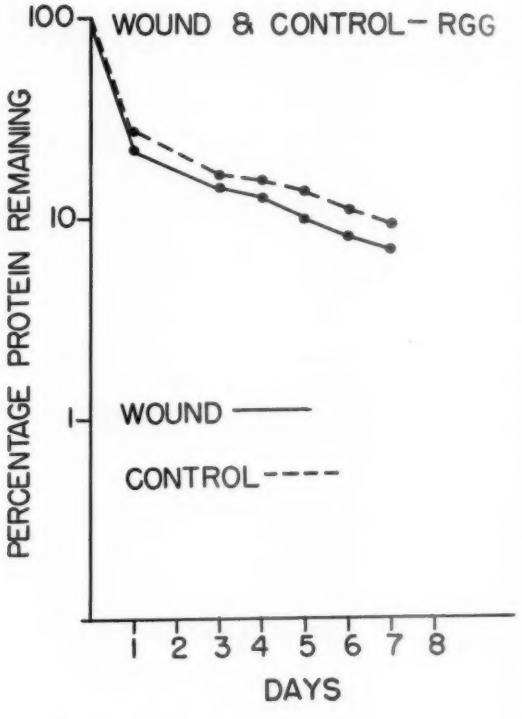


Fig. 6.



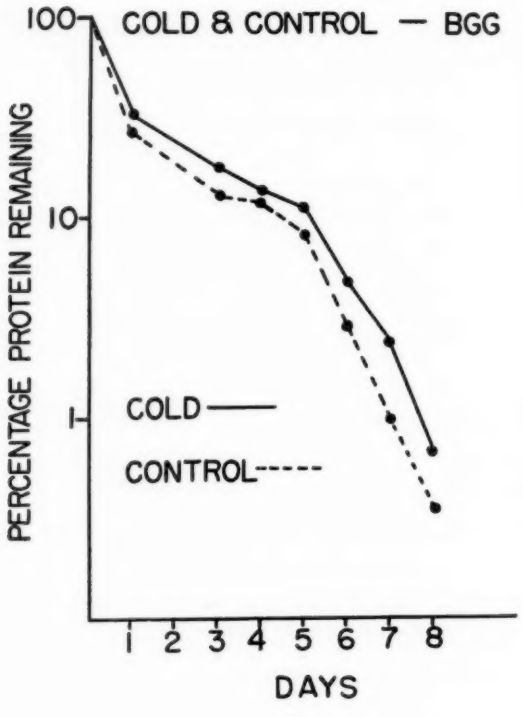


Fig. 7.

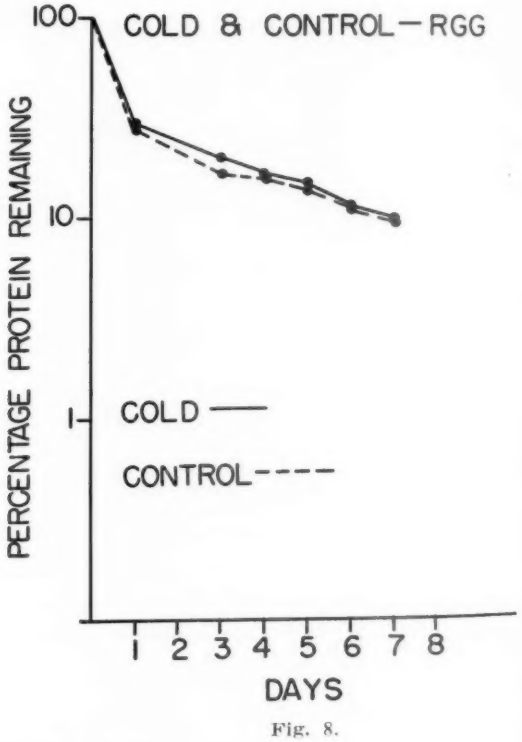


Fig. 8.

Figs. 5 to 8.—(See legend, p. 963.)

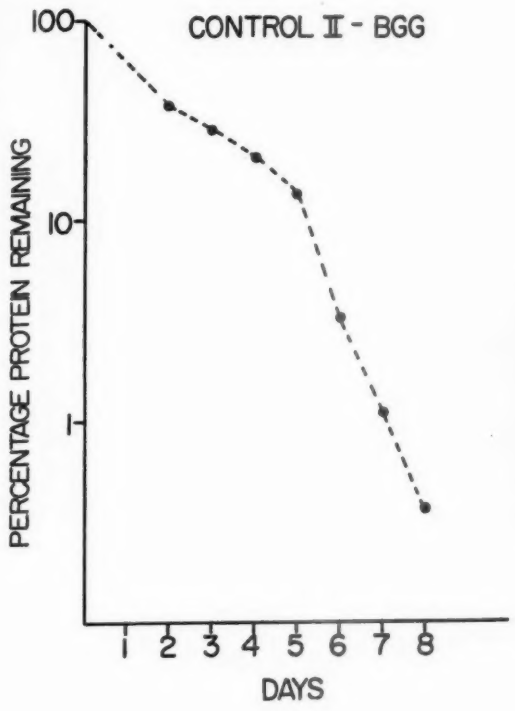


Fig. 9.

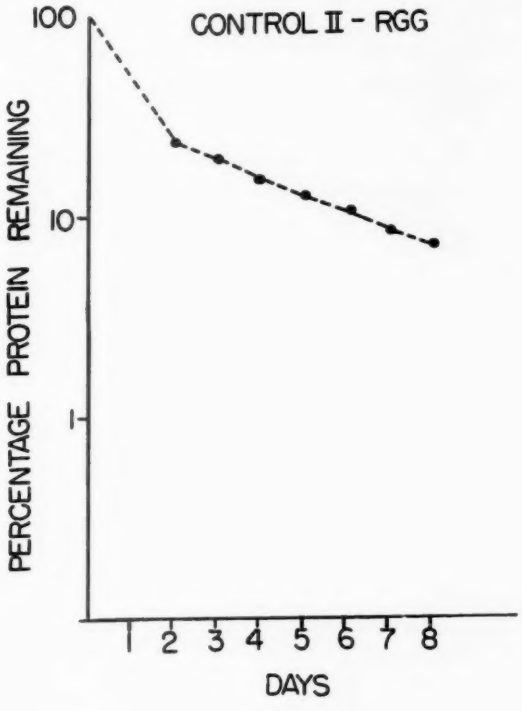


Fig. 10.

Figs. 9 and 10.—These show the degradation curves of BGG and RGG in untraumatized rabbits of Table II.

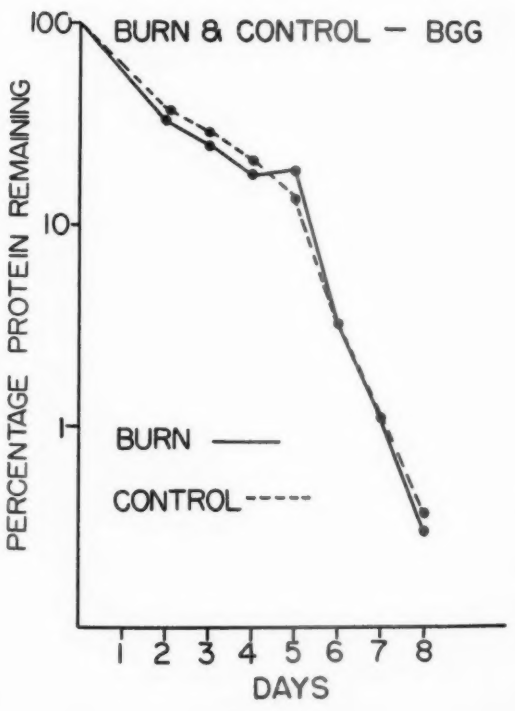


Fig. 11.

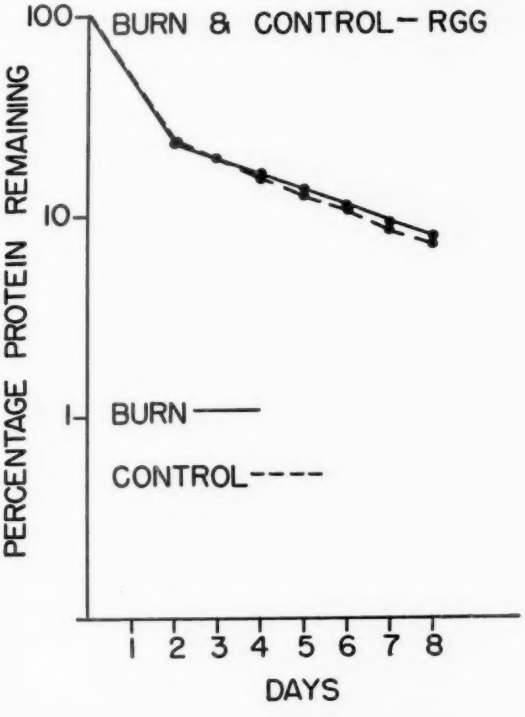


Fig. 12.

Figs. 11 and 12.—These compare the handling of BGG and RGG by burned animals with their controls.

the method of simple incision and drainage. After the sample had been thoroughly mixed in its heparin-coated tube, 1.00 ml. of each was placed in a well-type scintillation counter and counted on an Atomic Scaler (Model 111) having a counting delay of less than 1 μsec. All aliquots were counted for at least ten times and more often 100 times the background activity.

Data from these experiments are summarized in Tables I and II. Figures 1 to 8 and 9 to 12, respectively, are graphic representations of the same information. Parameters were analyzed statistically by the analysis of variance technique and application of the "F" test,[32] instead of by the ADR (antigen disappearance rate) method suggested by Talmage and associates.[35] Only figures derived from the third day onward were analyzed so that the process of mixing would not affect the results. Analyses were performed on three separate pools of data: (1) all BGG from Table I, (2) fracture and control RGG from Table I, and (3) all BGG and RGG from Table II. Since the plots of the cold and wound RGG from Table I are so obviously superimposable, it did not seem worth while to subject the data from which they were derived to statistical manipulation.

Every rabbit was killed with an overdose of barbiturate at the conclusion of the experiment. Autopsy and gross inspection revealed no complicating diseases.

RESULTS

Most of the conclusions one would reach by inspection of the graphs were borne out by the tests of significance. The moderate difference in the trends of the control and fracture RGG was not significant. The rabbits subjected to cold and wounds did not handle BGG differently from their control or from each other. Burn wounds did not wreak a change in the catabolism of either homologous or foreign globulin. The fact that at one point the curve of the burned-BGG rabbits crossed that of the unharmed ones was not significant. The surprising observation was that those animals with a fractured tibia manifested the inflection in the BGG curve significantly earlier (probability <0.01) than did any other group in Table I.

DISCUSSION

These experiments clearly show that under the experimental conditions, trauma in the form of a thermal burn, wound, or exposure to cold did not alter the rate of antigen catabolism and hence, by inference, did not result in a demonstrable effect on antibody production immediately after trauma. This conclusion contradicts a number of other observations that might lead one to expect any slight deviation from absolute homeostasis to derange the antibody mechanism. It coincides, however, with the clinical work of Havens, Bock, and Siegal,[19] and it is compatible with the findings of Balch.[1] These authors point out that depletion, malnutrition, and some post-traumatic states do not alter antibody production. Of course it is still possible that prolonged depletion superimposed on a post-traumatic state would change the immune response.

The puzzle in our data is the effect of fractures upon antigen catabolism. Assuming that the handling of homologous protein by rabbits with fractures is similar to that of the control animals—although employment of larger numbers of animals might serve to make the visual impression of their slight disparity actually significant—it is inexcapable that a fracture speeds the degradation of antigen by the rabbit; therefore, antibody production is very likely accelerated.

The best solution to this enigma was proposed to us by Prof. Albert H. Coons on the basis of his work with Robert White.[37] He suggested that a callus forming around a fracture shortly after the intravenous injection of antigen may possibly act as a natural granuloma and increase antibody fabrication in the same way as artificial granulomas of antigen-with-alum. Antigen is kept in the periphery, in contact with the sites of antibody production, instead of being allowed to disappear into immunologically inactive recesses of the organism. Reference to Menkin's[29] classic studies on localization and trapping of circulating foreign protein at sites of focal inflammation makes it highly likely that the callus in this experiment is a nidus of impounded antigen. Of course, immunohistochemical studies of antigen and antibody localization at the fracture locus would verify or disprove this hypothesis.

A much less satisfactory explanation is based upon the observation that estrone may act strikingly to increase the antibodies formed on primary immunization.[36] Since some fractures can call forth a greater hydroxycorticoid response in the organism than can major burns,[30] it is within reason that high levels of adrenal corticoids could stimulate antibody production if they were metabolized to an estrogenic product. We hold little brief for this proposal.

If these results are applicable in the clinic as well as in the animal laboratory, then we still must discover why the moderately burned patient (with a presumably intact antibody mechanism) cannot eliminate colonizing bacteria.* Current investigation has illuminated more and more the role of extraimmunological processes in the defense against infection, and perhaps such mechanisms provide the explanation for the inordinate hospitality of the burned host.

Dubos[7] has succinctly described some of the body's basic biochemical processes that ward off invaders. Pillemer[31] has begun to investigate the workings of the properdin system, which in all probability explains many phenomena of innate resistance and makes comprehensible the species differences in susceptibility to infection. Among the most exciting developments in the field of extraimmune resistance, too, is the unequivocal demonstration by Evans and Perkins[11] that intraperitoneal injection of *Hemophilus pertussis* vaccine causes a substantial specific immunity to intracerebral innoculation of virulent *H. pertussis* within five hours. Immune bodies of a novel sort may be involved in such a resistance, or perhaps an unexplored process similar to that of viral interference is operative.

*One difficulty in transferring these conclusions directly to the problems of man is that the human being secretes predominantly hydrocortisone into his adrenal vein in times of stress, but the rabbit under corticotropic stimulation releases quantities of corticosterone along with or instead of hydrocortisone.[21] Hydrocortisone is a potent suppressor of the immune mechanism, but corticosterone is relatively inert.

In any case, experiments of these workers and others indicate that the field of resistance to infection is still far from closed, as many think it is. The surgeon, separated from bacteria so much of his life only by the thickness of a rubber glove, should certainly be among those who cultivate this fertile soil.

SUMMARY

The inability of the burned patient to rid himself of colonizing bacteria may be a manifestation of impaired antibody production. The purpose of this experiment was to find out whether traumatic experience depresses the immune mechanism, since it is known that some of the individual facets of the response to trauma are among the conditions that do so.

Determination of the disappearance rate of radio-iodinated bovine gamma globulin in rabbits was employed as an indication of antibody-production; radio-iodinated rabbit gamma globulin served as a control on nonspecific protein turnover.

Wounds, full thickness burns, and exposure to cold did not alter the catabolism of either protein. The group of animals subjected to a fracture of the tibia unexpectedly showed a significantly earlier and greater antibody response than did any other series. A mechanism is proposed to account for this observation.

Examples of extraimmune mechanisms in the defense against infection are cited.

From the planning to completion of this experiment, many people generously contributed their special knowledge:

Drs. Frederick G. Germuth, Albert H. Coons, and Charles P. Summerall, III; Dr. William E. Reynolds, Dr. Mindel C. Sheps, and Miss Rita Nickerson of the Department of Preventive Medicine, Harvard Medical School and Department of Biostatistics, Harvard School of Public Health.

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THE INFLUENCE OF TEMPERATURE UPON ISCHEMIC RENAL DAMAGE

GEORGE M. BOGARDUS, M.D.,* AND RALPH J. SCHLOSSER, M.D.,**
SEATTLE, WASH.

(From the Department of Surgery, University of Washington School of Medicine)

THE purpose of this paper is to report the influence of lowered renal temperature upon ischemic damage to the canine kidney resulting from renal pedicle occlusion.

> The potential ischemic effects of temporary arrest of the circulation upon the tissues distal to the point of occlusion during the performance of aortic resection is an important matter. . . . In general, it may be assumed that the higher the lesion the greater is the likelihood of ischemic damage from temporary aortic occlusion. Accordingly, this factor assumes particular importance in fusiform aneurysm located in the descending thoracic and upper abdominal aorta where temporary aortic occlusion would be done above such vital organs as the spinal cord and kidneys, long recognized to be highly sensitive to acute diminution in blood supply. . . . The safe period for occlusion of the descending thoracic aorta has not been accurately determined, and according to reported experience, is quite variable.[1]

The pattern of recovery of renal function after periods of renal ischemia produced by renal artery or aortic occlusion up to two hours has been studied.[2] The damage, as evidenced by renal function studies, was quite severe at first, but gradually approximated normal after about three weeks. More recent studies by Friedman and associates[3] revealed that a marked functional ischemia persisted for several hours after release of the clamp, but restoration of blood flow was substantially complete in twenty-four hours. Other renal functions were restored over a period of weeks. In the dog experiments, the occluding clamp was in place for two hours. These authors concluded that renal function was depressed to negligible levels for about twenty-four hours, then slowly improved during the next two weeks.

Certain studies have revealed that renal function is proportional to temperature.[4]

> The respiration of rat kidney cortex slices drops to a very low level at 0.2° C. This level is fully established at the end of the fifteen minute equilibration period and does not change within the limits of error of our measurements

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*Clinical Instructor in Surgery.
**Instructor in Surgery.

for the ensuing hour. When the tissue is returned to the bath at 37.7° C. there is complete recovery of the capacity for oxygen consumption. The periods of cooling and of rewarming did not exceed fifteen minutes each.

Owens and associates[5] carried out the following experiments related to aortic occlusion and general hypothermia.

Sixteen dogs were subjected to occlusion of the thoracic aorta while their rectal temperatures were in the range of 23° to 26° C. A noncrushing clamp was placed across the upper third of the vessel in seven dogs. In five of the animals, the aorta was occluded for 90 minutes. In a second series, the middle third of the thoracic aorta was occluded, for 90 minutes in seven animals and for 180 minutes in two. No neurological changes were observed in any of the 16 dogs.

In three of these animals, renal function was studied by observations of glomerular filtration rate (using creatinine clearance) and renal plasma flow (paraminohippuric acid). These observations were made 24 hours before and again 24 hours after the operation. No significant change was found in the postoperative studies, thus suggesting that no renal damage had occurred.

METHODS

The following experiments were conducted with a view to ascertaining the degree to which lowered renal temperature might alter the response to occlusion of the renal pedicle in the dog, as measured by blood creatinine levels.

Series A.—Five mongrel dogs were lightly anesthetized with Nembutal. The abdomen was opened through a midline incision and each renal pedicle was occluded for one hour, after drawing blood for control levels of creatinine.

Series B.—Five mongrel dogs were lightly anesthetized with Nembutal. The abdomen was opened through a midline incision and each renal pedicle was occluded for two hours, after drawing blood for control levels of creatinine.

Series C.—Eight mongrel dogs were lightly anesthetized with Nembutal. The abdomen was opened through a midline incision and each renal pedicle was occluded for two hours, after drawing blood for control levels of creatinine. In addition, each kidney was packed in ice during the period of occlusion. In six of these eight animals, the renal temperature was recorded by means of an iron-constantan recording thermocouple, thrust into the renal parenchyma.

Series D.—Two mongrel dogs were lightly anesthetized with Nembutal, the abdomen was opened and each ureter catheterized. Both renal pedicles were occluded for one hour and during the period of occlusion one kidney of each dog was chilled with ice. Phenolsulfonephthalein excretion was measured from each kidney for one hour after the period of occlusion.

RESULTS

In Series A, B, and C, blood creatinine levels were followed postoperatively. The results are presented in Figs. 1 to 3. The recorded renal temperatures are shown in Fig. 4. The phenolsulfonephthalein excretion collected in Series D is shown in Fig. 5. The creatinine levels remained low in the animals which endured renal pedicle occlusion for one hour. Two hours of renal pedicle occlusion, without cooling, resulted in a rise of creatinine to as high as 13.4 mg. per cent. Chilling the kidneys of animals which endured two hours

of renal pedicle occlusion resulted in less rise in blood creatinine, the highest figure being 3.01 mg. per cent. The temperature range varied between 16° C. and 30° C., staying mainly around 20° to 25° C. The observation of phenol-

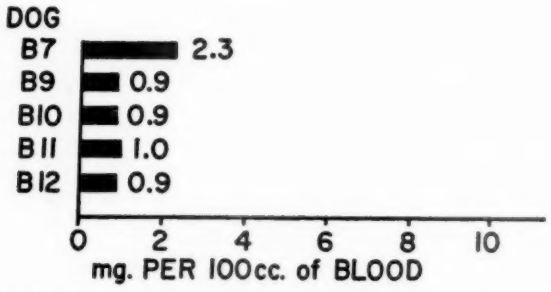

Fig. 1.—Highest level of blood creatinine obtained after one-hour occlusion of the renal pedicle.

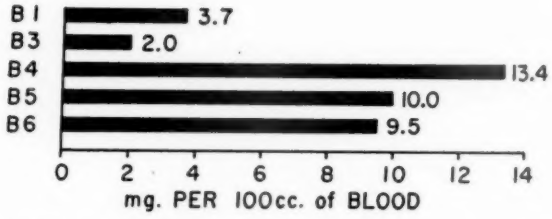

Fig. 2.—Highest level of blood creatinine obtained after two hours of renal pedicle occlusion, without cooling of the kidneys.

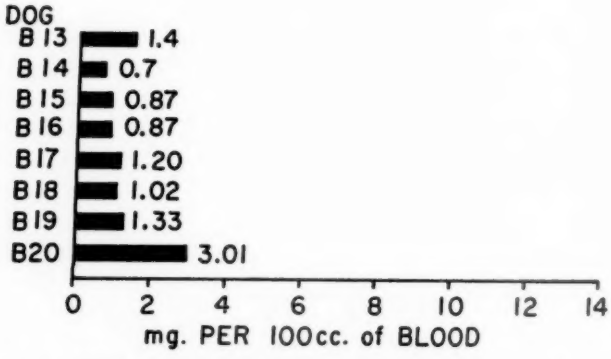

Fig. 3.—Highest level of blood creatinine obtained after two hours of renal pedicle occlusion with cooling of the kidneys.

sulfonephthalein excretion revealed that the chilled kidneys yielded a more prompt return of function with a larger volume of urine and larger amount of phenolsulfonephthalein excretion.

Two dogs with occlusion for one hour died from no apparent cause. Three of the dogs occluded for two hours died, one from intestinal obstruction and two from undetermined causes. None of the dogs with chilling of the kidneys died.

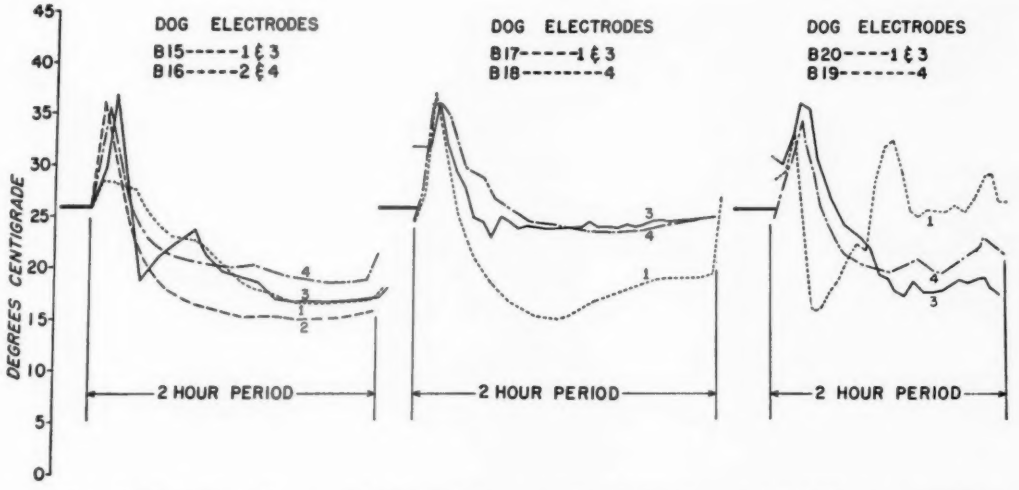

Fig. 4.—Indicates the recorded renal temperature from the cooled kidney parenchyma, using an iron-constantan thermocouple, in each kidney of Dogs 15, 16, 17, and 18. In Dogs 19 and 20 only one renal temperature was recorded.

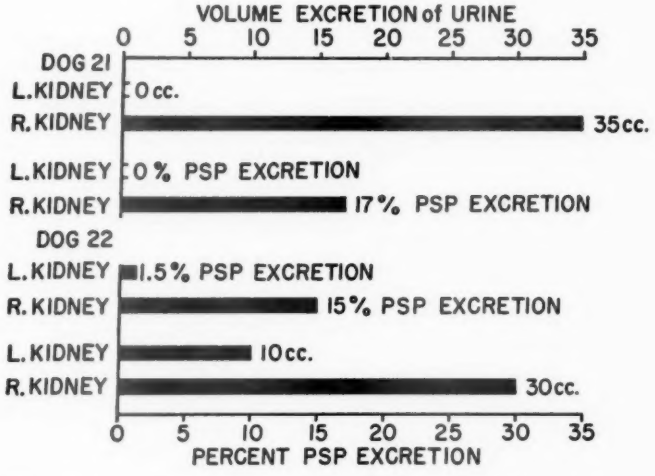
VOLUME EXCRETION of URINE
0 5 10 15 20 25 30 35
DOG 21
L.KIDNEY 0 cc.
R.KIDNEY 35cc.
L.KIDNEY 0 % PSP EXCRETION
R.KIDNEY 17 % PSP EXCRETION
DOG 22
L.KIDNEY 1.5 % PSP EXCRETION
R.KIDNEY 15 % PSP EXCRETION
L.KIDNEY 10cc.
R.KIDNEY 30cc.
0 5 10 15 20 25 30 35
PERCENT PSP EXCRETION

Fig. 5.—Volume of urine and per cent of phenolsulfonephthalein excretion, with and without cooling of the kidney. The right kidney in each case was chilled with an ice pack; the left kidney remained at body temperature.

SUMMARY

Two hours of renal pedicle occlusion in the dog resulted in a considerable rise of blood creatinine in three of the five dogs. Chilling of the canine kidney, during a two-hour period of renal pedicle occlusion, resulted in a less marked

rise in creatinine in all of eight dogs. Each of two canine kidneys which endured one hour of renal pedicle occlusion with chilling excreted phenolsulfonephthalein more quickly and in larger volume than the kidneys not chilled during the period of occlusion.

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PSEUDOMEMBRANOUS ENTEROCOLITIS

J. Harvey Johnston, Jr., M.D.,* Carl D. Brannan, M.D., and
Kenneth M. Heard, M.D.,** Jackson, Miss.

(From the Surgical Clinic and Mississippi Baptist Hospital)

PSEUDOMEMBRANOUS enterocolitis (diphtheritic enteritis, antibiotic enterocolitis, staphylococcal enterocolitis, acute necrotizing enteritis), once regarded as a rare post-mortem finding, is being encountered clinically and at autopsy with increasing frequency. Although the entity was described pathologically long prior to the antibiotic era, there is little doubt that the appreciable increase in incidence of the disease coincides with the widespread use of broad spectrum antibiotics. Reports from the Mayo Clinic[1, 3, 6] contend that there has not been any increase in the incidence of fatal acute pseudomembranous enterocolitis since the advent of chemotherapeutic agents and antibiotics. Numerous reports and our personal experience in the past several years would tend to refute this belief.

In the last three years at the Mississippi Baptist Hospital there have been four autopsy cases in which pseudomembranous enterocolitis played a major role in the fatality. During this period of time, there were 954 hospital deaths and 273 autopsies, a rate of 28 per cent. As the diagnosis was not suspected in three of the four autopsy cases, it is not unlikely that the entity played a significant and unrecognized role in other deaths not examined by autopsy. It is obvious that pseudomembranous enterocolitis is an increasingly important cause of death and has usually not been recognized sufficiently early to institute adequate treatment. This is borne out by the prohibitive mortality of reported cases: in twenty-two cases collected by Speare[8] there were nineteen deaths and three survivals.

A brief summary of the autopsy cases in which pseudomembranous enterocolitis entered prominently in the fatal outcome follows:

Case 1.—H. C. S., a 62-year-old physician, presented mild diarrhea of unknown etiology. Believing this to be due to *E. histolytica*, he empirically took oxytetracycline,† 2 Gm. daily for ten days. This markedly aggravated his condition resulting in passage of 20 to 25 dysenteric stools daily. Repeated stool studies were negative for amoebae or enteric pathogens. Proctoscopic examination showed the mucosa of the lower bowel to be diffusely edematous, indurated, and reddened. There were multiple shallow ulcers, varying from 3 to 5 mm. in diameter, covered with a yellowish gray membrane. The clinical

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*The Surgical Clinic and The Mississippi Baptist Hospital.
**Pathologist, Mississippi Baptist Hospital.
†Terramycin (Chas. Pfizer & Co., Inc.).

impression was acute ulcerative colitis, although the patient insisted that his trouble was due to oxytetracycline, so emphatically that the manufacturer sent a representative for consultation.

Because of marked weight loss, high fever, abdominal cramps, and continued dysentery, ileostomy was accepted by the patient as a procedure of last resort. At operation the entire colon and distal ileum were found to be indurated and thickened. Large doses of penicillin and streptomycin were given before and after operation. Maintenance of fluid and electrolyte balance was achieved only with great care. Nine days after ileostomy, because of left phlebothrombosis, bilateral superficial femoral vein ligation was carried out. Despite postoperative anticoagulant therapy, fatal pulmonary embolism occurred six days later.

Autopsy showed massive pulmonary embolism and "generalized ulcerative colitis."

Comment.—In retrospect, it seems likely that this was a severe case of acute pseudomembranous enterocolitis due to oxytetracycline and aggravated by other antibiotics. Probably the failure to appreciate this resulted in the patient's death.

CASE 2.—J. F. C., a 45-year-old white woman, had a colostomy performed elsewhere when exploratory laparotomy revealed a suspicious lesion in the rectosigmoid. She received large doses of penicillin and streptomycin prior to admission.

Her hospital course was one of spiking fever, abdominal distention, and passage of frequent, malodorous, liquid stools through the colostomy. Intensive antibiotic therapy with intramuscular streptomycin and intravenous oxytetracycline failed to alter this course. Several days after revision of the colostomy, she died in circulatory collapse despite vigorous supportive therapy.

Autopsy showed extensive acute pseudomembranous enterocolitis, an endometrioma of the rectosigmoid, and moderate bilateral pyelonephritis.

Comment.—Unquestionably the failure to recognize an overwhelming pseudomembranous enterocolitis secondary to antibiotics resulted in this fatality. It is particularly unfortunate, for the patient was relatively young and presented a benign bowel lesion.

CASE 3.—W. H. G., a 67-year-old hypertensive arteriosclerotic, sustained an intertrochanteric fracture of the right hip. Surgical consultation was sought five days later because of abdominal distention and feculent vomiting; this was thought to be due to adynamic ileus. Despite Wangensteen suction, intravenous fluids, and blood, profound circulatory collapse which responded temporarily to l-arterenol and cortisone ensued. Death occurred three days later in a similar episode of irreversible shock. The patient had received 400,000 units of penicillin with 1 Gm. of streptomycin daily during his hospital stay.

Autopsy showed a fractured hip, bronchopneumonia, and an incidental cortical adenoma of the right adrenal. There was extensive pseudomembranous enterocolitis, particularly marked in the transverse colon, where sharply circumscribed ulcers with dirty, reddish brown bases to 15 cm. in greatest diameter were found. Microscopically the ulcers were filled with necrotic debris and extended to the muscularis.

Comment.—Although senility and injury were contributory, death resulted from late circulatory collapse, probably due to enterocolitis.

CASE 4.—J. B. H., a 54-year-old white man, sustained a crushing chest injury, fracturing the clavicle and five ribs on the left. Penicillin (400,000 units daily) was begun on admission and continued until his death ten days later. Abdominal distention was marked two days after injury. Four days later he became very weak, mildly cyanotic, and slightly dyspneic.

He presented evidence of mild shock associated with marked abdominal distention. Electrocardiogram changes were present but interpreted as evidence of right ventricular strain or distortion from displacement of the heart by abdominal distention. Pulmonary embolism was considered a likely possibility. Despite symptomatic treatment with vasopressors, blood, ACTH, and anticoagulants, improvement failed to take place. Severe diarrhea was noted two days later and death ensued with shock and abdominal distention being prominent clinical features.

Autopsy revealed fractures as described and minimal traumatic pancreatitis with a small hematoma adjacent to the tail of the pancreas. The ileum and transverse colon were greatly distended and presented marked reddening of the mucosa with patchy areas of ulceration.

Comment.—The immediate cause of death was shock associated with pseudomembranous enterocolitis. Fluid and electrolyte imbalance (hypokalemia) may have been contributory.

DIAGNOSIS

The increasing frequency and overwhelming course of pseudomembranous enterocolitis make it mandatory that we establish the diagnosis earlier and more often. The first step is an obvious one, that is, to become cognizant of the incidence of the varied clinical manifestations of the entity. When suspected, a stool smear and culture (on blood agar media, for the growth of other organisms on the usual culture media will often suppress *Micrococcus pyogenes,* which is the usual offender) is indicated. Perhaps the ideal precaution would be to make fecal smears on all patients receiving large or prolonged doses of antibiotics,[6, 8] particularly those of the tetracycline group or the combination of penicillin and streptomycin. Such smears would show a striking absence of the gram-negative flora and a preponderance of gram-positive cocci in patients with pseudomembranous enterocolitis.

CLINICAL PICTURE

Study of the autopsy cases, personal clinical experience with the disease, and review of the literature would indicate that pseudomembranous enterocolitis most often manifests itself as one of the following clinical pictures (although the underlying pathology is the same!):

1. *Choleric Type,* characterized by profuse watery diarrhea, nausea, vomiting, periumbilical cramps, abdominal distention, and fever. If appropriate therapy is not vigorously instituted, irreversible shock with death will ensue.

This type is the most frequent and is recognized more often clinically, for physicians have become cognizant of diarrhea as a manifestation of antibiotic toxicity.

2. *Ileus Type,* in which increasing abdominal distention, not responding to nasogastric suction removing copious amounts of greenish brown fluid, nausea and vomiting (despite suction), and respiratory embarrassment from increasing distention are evident. Diarrhea may be present but often is not. Shock will occur but is usually not as dramatic as in Type 1.

Diagnosis here is difficult. The condition most often occurs postoperatively, particularly after colon and gastric surgery, and clinically resembles very closely severe adynamic ileus, peritonitis, or postoperative acute pancreatitis. Only a knowledge of this clinical picture supported by adequate stool smears and cultures will result in recognizing the condition so that the antibiotics being given can be promptly discontinued and vigorous therapeutic measures instituted. Failure to recognize this ever-increasing postoperative complication will lead to loss of the patient's life. The natural inclination when one is not cognizant of this possibility is to increase the number and dosage of antibiotics administered to the patient, which course is uniformly a fatal one.

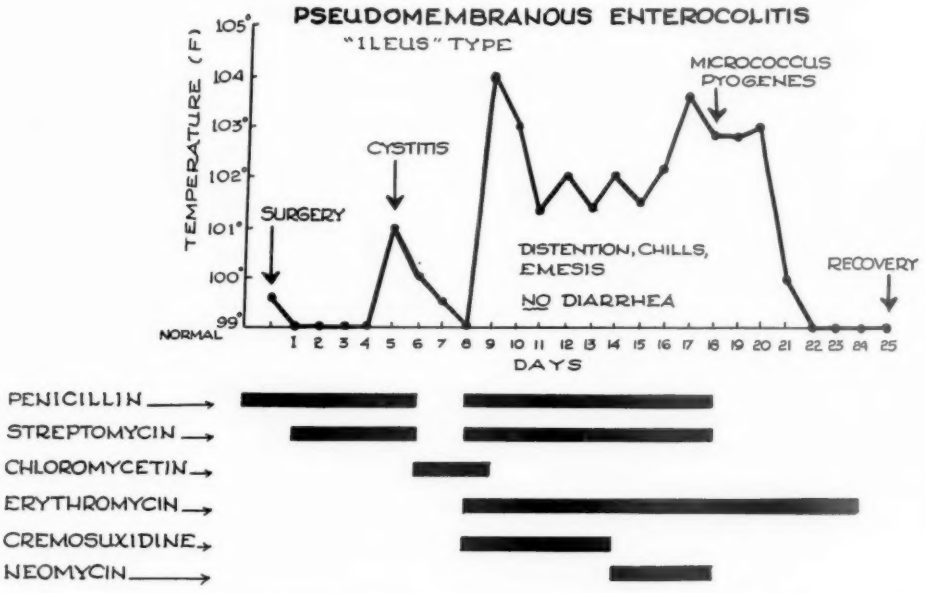

Fig. 1.—Ileus type of pseudomembranous enterocolitis. Chart showing fever curve and varied antibiotic dosage, emphasizing marked distention but absence of diarrhea.

We have had personal contact with seven patients of this type in which prompt recognition of the complication, discontinuance of antibiotics being given, vigorous antishock measures, and erythromycin have led to recovery. The following is typical of this group:

Mrs. B. F. D., a 61-year-old white woman, was explored with a diagnosis of twisted ovarian cyst. Acute diverticulitis of the sigmoid with a localized abscess in the mesocolon was found; the involved area of the sigmoid was resected and primary anastomosis effected.

The early postoperative course was gratifyingly smooth (Fig. 1); large doses of penicillin and streptomycin were given. On the ninth postoperative day, the patient had a chill and presented fever of 104° F. Stormy febrile course with increasing abdominal distention, nausea, and vomiting (but no diarrhea) continued despite intensification and variation of antibiotics.

Believing the patient to have a leaking anastomosis with generalized peritonitis, one of us (J. H. J.) was asked to see the patient in consultation. Gram stain of an anal swab

showed a marked preponderance of gram-positive cocci and substantiated the consultant's diagnosis of pseudomembranous enterocolitis. Stool culture showed almost a pure growth of hemolytic staphylococcus *(Micrococcus pyogenes)*.

Discontinuance of all antibiotics except erythromycin and strong supportive therapy resulted in dramatic improvement in seventy-two hours (Fig. 1).

3. *Precipitous Shock Type.* Occasionally the more common symptoms of diarrhea, abdominal distention, nausea, and vomiting are absent or overlooked because of their minor nature. One is suddenly confronted with a patient in mild to moderate shock with marked hypotension, tachycardia, pallor, sweating, and, not infrequently, dyspnea. The onset is usually dramatic and suggests the possibility of pulmonary embolism or coronary thrombosis. The increasing frequency of pseudomembranous enterocolitis would warrant its being considered when such a picture is presented postoperatively.

The following case emphasizes this clinical type:

Mrs. L. B. M., a 70-year-old white woman, presented a large esophageal hiatus hernia with esophagitis, mimicking heart disease. Transthoracic repair was easily effected. Forty-eight hours later, after receiving five injections of 400,000 units of penicillin and 0.5 Gm. streptomycin, the patient presented shock, disorientation, and a positive Babinski reflex on the right. Myocardial infarction versus left cerebral thrombosis were the diagnoses strongly considered by medical consultants. Shortly thereafter diarrhea developed and the diagnosis of pseudomembranous enterocolitis was established. Substitution of erythromycin for penicillin and streptomycin, l-arterenol, blood, and so on, resulted in prompt improvement with discharge on the twelfth postoperative day.

Comment.—This case is instructive in that (a) short dosage of penicillin and streptomycin precipitated pseudomembranous enterocolitis, which was (b) characterized by severe shock and minimal neurological signs at the onset with subsequent development of diarrhea.

TREATMENT

The most important step in therapy would be to decrease the incidence of pseudomembranous enterocolitis by administering antibiotics only when specifically indicated and choosing them in knowledge of their potential complications.

The "routine" use of antibiotics following major surgery to avoid wound infection is a particularly dangerous practice. Such therapy flirts with a serious, often fatal complication to avoid an infrequent, usually inconsequential wound infection.

The second most important therapeutic consideration is earlier diagnosis, for only then can death be avoided. A healthy suspicion of the possibility will lead to periodic stool smears and cultures to be aware of changing intestinal flora and avoid overgrowth of virulent organisms.

In the management of the clinically established case, the following therapeutic recommendations are important:

1. *Discontinuance of the antibiotics being given* (for the offending intestinal organisms are usually resistant to these drugs) and prompt institution of specific antibiotic therapy. At the present time the drug of choice seems to be

erythromycin, for most of the hemolytic staphylococci are susceptible to it. Erythromycin should be continued until antibiotic sensitivity studies disclose the drug of choice. Unfortunately, past history will probably repeat itself in that we will see increasing numbers of organisms which become resistant to erythromycin, as has been true in the case of other antibiotics. Our most recent case of pseudomembranous enterocolitis was apparently due to a combination of hemolytic staphylococcus and streptococcus, both resistant to erythromycin and all other antibiotics tested.

2. *Antishock measures.* The shock is often so profound that l-arterenol will be necessary to maintain adequate circulation while the fluid and electrolyte losses are being vigorously restored. Such deficits are large and will require similar replacement. By using the previous eight-hour losses as a guide and by daily determinations of chlorides, carbon dioxide-combining power, sodium and potassium levels, adequate replacement can be accomplished. Repeated whole blood transfusions seem to be of distinct value.

3. *Corticotropin or cortisone.* There would seem to be danger in the use of these drugs during the acute stage of enterocolitis for the infection may be disseminated. However, Prohaska and associates,[7] after observing four deaths, decided to use corticotropin in pseudomembranous enterocolitis (20 mg. every six hours) and were struck with the dramatic, prompt improvement and survival of three patients handled in this manner.

Cortisone seemed to be lifesaving in the following case:

Mrs. C. F. L., a 63-year-old woman, was admitted with intestinal obstruction due to an adenocarcinoma of the distal transverse colon. Stamm cecostomy under local anesthesia effectively decompressed the bowel in seventy-two hours. Definite surgery was deferred for ten days after decompression because of episodes of auricular fibrillation with syncope. During this period she received 800,000 units of penicillin, 1 Gm. of streptomycin, and 8 Gm. of Sulfathalidine daily. The resected colon presented an obstructing adenocarcinoma, an incidental adenomatous polyp, and early pseudomembranous enterocolitis. Abundant gram-positive cocci were evident. Large doses of penicillin, streptomycin, and intravenous erythromycin were continued prior to establishing the diagnosis of pseudomembranous enterocolitis. Six days after surgery the patient presented profound shock. Continuous l-arterenol drip and cortisone (200 mg. daily) successfully resuscitated the patient, allowing discharge twenty days after colon resection.

Comment.—Dramatic, striking improvement occurred six hours after corticoid therapy was started.

The usual supportive therapy, such as gastrointestinal suction, tracheobronchial toilet, and so on, is of utmost importance in these seriously ill patients.

SUMMARY

A review of our experience, citing autopsy and appropriate clinical cases, is given to emphasize the varied clinical picture of pseudomembranous enterocolitis, an entity of increasing frequency and tremendous lethal potential, is reported.

The disease usually manifests itself as one of three clinical types: (a) "choleric," (b) ileus, or (c) profound shock. Cognizance of the varying types is essential to early diagnosis, which is all-important in overcoming the prohibitive mortality reported in the literature. Stimulated by the first death reported here, it has been possible to recognize pseudomembranous enterocolitis in fourteen cases early enough for vigorous therapy to effect survival in all.

As the entity occurs most often after surgery and trauma, surgeons should be aware of the complication, striving to recognize it in its incipiency to avoid a preventable death.

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HOLDER FOR TWO LEGS*

RICHARD W. ZOLLINGER, M.D., COLUMBUS, OHIO

(From the Surgical Service, Mt. Carmel Hospital, and the Department of Surgery, Ohio State University College of Medicine)

THE preparation of one or more extremities at the time of surgery usually requires more than one person. The individual holding the leg or legs finds it tiresome, heavy manual labor. The surgeon or assistant preparing the leg often speeds the preparation to a point of inefficiency in order to alleviate the groans of the human leg holder.

The holder which I have designed and am going to describe, we have found to be practical (Fig. 1).

CONSTRUCTION

It consists of three main parts, all made of light metal such as aluminum. These parts are: (1) the main piece, termed the "holder," and (2) two side bars.

1. The main piece, termed the "holder," is approximately 36 inches in length. It is indented in six places so that there are three indentations to each side of the center of the main piece. Each indentation is approximately three inches in depth and easily holds the heel of the patient.

2. The side bars, which are roughly 30 inches in length and of light metal, are attached to the under surface of the main leg holder with a carriage bolt, plus a washer and wing nut. In this way it is possible to shift the position of the side bars, thus varying the distance between them. This feature makes it possible to attach the holder to practically all operating tables. Such an arrangement also makes the assembly easy and quick and it may be as easily disassembled for transportation.

The holder, with the two side bars, is then positioned in the slots ordinarily used for the footboard. Since each of these slots moves backward and forward on a metal piece and is outfitted with a metal thumbscrew, it is possible to move the side bars on the leg holder backward or forward and upward to a distance of 30 inches, or down to the table level.

USE

We have found this holder to be especially useful for the preparation of the lower extremities for venous strippings for varicose veins. It also makes access to the short saphenous system easy without repositioning the patient on the operating table. It may be useful for other soft-tissue surgery on the lower extremity and it has been used for the holding of an extremity for approximation of a fractured patella.

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*Manufactured by Zimmer Manufacturing Co., Warsaw, Ind.

In the stripping of veins for varicosities, we have used it in the following manner:

1. After the patient is anesthetized, the holder is placed on the operating table, and the heels are placed in the indentations on either side of the center of the leg holder. The indentations used depend upon the size of the extremity and the feet may be placed as far as 30 inches apart if the most lateral indentations are used for the two heels. This makes the upper portion of the thigh easily accessible for preparation and future surgery.

2. The holder is then pushed upward for any distance that the surgeon desires and it is also moved backward and forward so that it just fits the length of the extremity which may be long or short.

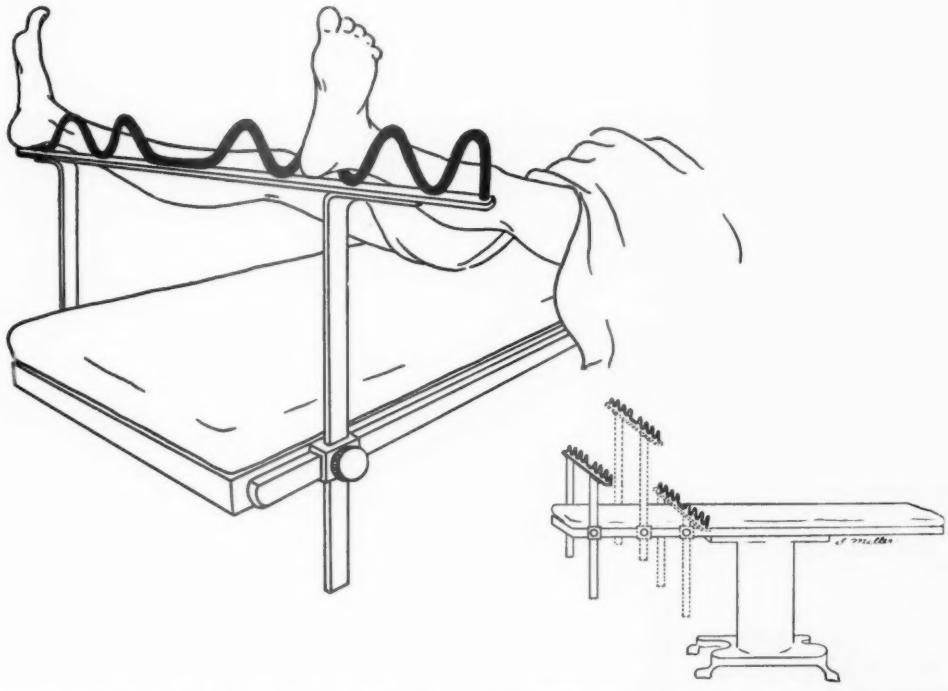

Fig. 1.—The holder, its attachment, and possible positioning on the surgical table are illustrated.

3. Once the legs are positioned, and the side bars are fixed by tightening the thumbscrews on the operating table, the holder is in a rigid position and the legs become readily accessible for preparation for surgery.

4. The holder itself may be draped. Then the extremities may be separately draped and the entire holder is then dropped down to table level.

5. The operation then proceeds with ligation of the upper end of the saphenous vein and all its tributaries and the placing of the strippers in the long saphenous system.

6. The holder may then be elevated in order to empty the blood from the superficial veins and, in this position, the previously placed strippers may be removed along with the varicosities. This maneuver markedly reduces the amount

of bleeding associated with this procedure. The wounds may then be sutured as the surgeon desires. If the short saphenous systems are incompetent, the elevated position makes the stripping procedure accessible to the surgeon with the least effort.

7. Since the legs are up and have been stripped, and the wounds have to be closed, the extremities are easily wrapped with compression bandages without the use of an extra individual to supply the labor as a human leg holder.

8. The holder may then be quickly removed from the table in a matter of seconds and placed in a corner of the operating room for future use.

CONCLUSION

The holder for two legs dispenses with the heavy labor required of the surgeon or assistant in preparation of extremities.

Case Reports

AORTIC EMBOLECTOMY FOLLOWING MITRAL COMMISSUROTOMY

FRANK R. DENMAN, M.D., AND HUGH H. HANSON, M.D., HOUSTON, TEX.

(From the Surgical and Medical Services of Hermann Hospital)

THE occurrence of peripheral thromboembolism during or after mitral commissurotomy is one of the major complications to be feared in the surgical treatment of mitral stenosis. This is particularly true in those patients with atrial fibrillation and a history of previous embolism. Bailey and associates[1] report a 4 per cent incidence of thromboembolism in all commissurotomies and a 10 per cent incidence in patients with previous embolism or atrial fibrillation. In patients with an established mother thrombus in the atrium, the incidence of operative embolism was 31.3 per cent.[1] Likewise, Warren, Linton, and Scannell[14] reported a 16 per cent incidence of embolism in all commissurotomies and a 30 per cent incidence in patients with previous episodes. Unfortunately, about 65 per cent of these emboli are cerebral and not surgically accessible. The ultimate reduction of mortality from cerebral thromboembolism must await the development of better methods of prevention; however, in instances where the embolus involves the aortic bifurcation or other critical peripheral vessels, prompt recognition and appropriate surgical therapy may be lifesaving.

The occurrence of an aortic saddle embolus is one of the gravest and most dramatic emergencies in medical practice, and when it occurs during the recovery period following major cardiac surgery it is indeed a catastrophic complication. Prior to the revival of surgical treatment for mitral stenosis, aortic saddle embolus occurred most often as a spontaneous complication in patients with mitral stenosis and fibrillation or from mural thrombi in patients with myocardial infarction. Wilkinson[16] in 1952 brought the total of reported cases of aortic embolism to 209. Pool and Farrar[11] in 1952 reported the thirty-third successful aortic embolectomy. White, Snyder, and Snyder[15] reported two additional cases in 1954. Blum[3] recently reported six cases with only one survival.

The first successful aortic embolectomy, following commissurotomy, was reported by Bloomberg and associates[2] in 1952, and Tropea and Entine[13] in 1953 reported two cases, in one of which embolectomy was successful. Moore and Harris[8] reported another in August, 1954, and Warren and co-workers[14] mentioned the occurrence of five aortic saddle emboli following mitral commissurotomy, three of which were removed with good results.

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Modoff, Thompson, and Streiber[7] in 1954 reported two cases of aortic embolus following mitral commissurotomy, in one of which embolectomy was successful.

Thus, in this résumé of the literature, there have been reported only forty-three successful aortic embolectomies, seven of which were performed in the immediate postoperative period following mitral commissurotomy. An additional case is reported here.

CASE REPORT

M. M. M., an unmarried, 35-year-old white woman, was admitted to Hermann Hospital on Oct. 25, 1953, for mitral commissurotomy. As a child, she had experienced aching pains in the knees and legs. Except for these she had been in relatively good health until 1941, when she had had a bout of double pneumonia. At the age of 24 years (1942), she developed severe dyspnea on exertion, palpation, orthopnea, and ankle edema. This was the first break in cardiac compensation and it responded well to bed rest, digitalis, and diuretics. At this time she was first told that she had rheumatic heart disease. Subsequently she worked as an office clerk until 1947, when she experienced a second break in compensation accompanied by rapid atrial fibrillation. This episode also responded to routine therapy. Subsequently she noted progressive dyspnea on exertion and more frequent episodes of palpitation despite adequate digitalization. On several occasions she experienced hemoptysis. However, she continued to work until March, 1951, when she was again placed at bed rest because of marked congestive failure and rapid atrial fibrillation. After compensation was regained, she continued to work. During the night of Sept. 2, 1952, she awakened suddenly to find that she could not move her right arm or leg. This paralysis was transitory and had disappeared in four to six hours without sequelae. In October, 1952, she was awakened one morning and found that she could not talk or use her right arm. At this time examination revealed controlled atrial fibrillation, a motor aphasia, and apraxia. There was also weakness of the right seventh and twelfth cranial nerves and the right arm. A diagnosis of cerebral embolus to a branch of the left middle cerebral artery was established and the patient was treated with bed rest, stellate block, and anticoagulants. She improved rapidly and was dismissed from the hospital after two weeks of treatment. This embolic episode was followed by a residual which resulted in some aphasia and dysarthria. However, by December the patient was back at work.

In August, 1953, she again developed marked dyspnea on exertion and orthopnea. She also noted weakness and easy fatigability. Despite adequate digitalization and mercurial diuretics, she was unable to maintain compensation and on Oct. 5, 1953, mitral commissurotomy was recommended.

The past history of this patient was otherwise noncontributory. Her family history was noncontributory. Personal history revealed that she smoked one package of cigarettes a day, partook of no alcohol, and drank one to two cups of coffee daily.

Physical examination revealed the patient to be 5′ 7½″ tall and to weigh 120½ pounds. Her temperature was 98.4° F., pulse markedly irregular and 100 to 112 per minute. The blood pressure was 100/70. She was orthopneic and dyspneic at bed rest. Examination of her head revealed a slight weakness of the right twelfth nerve and slight word aphasic and dysarthria. The neck veins were prominent and distended. Cardiac examination revealed a grade I apical diastolic thrill; slight cardiac enlargement to percussion; a soft grade I diastolic murmur in the aortic secondary area, and a diminished aortic second sound; and a grade I systolic murmur and soft grade II diastolic murmur were present at the mitral area. Auscultation of the lungs revealed moist râles throughout both lung fields. Abdominal examination revealed the liver edge to be palpable two fingerbreadths below the costal margin. The spleen was not palpable. All the arteries pulsated normally.

Laboratory studies revealed the following: urine-1.015 specific gravity, negative for albumin, sugar, and formed elements; hemogram-12.9 Gm. of hemoglobin, 4.04 million

erythrocytes, 10,250 leukocytes, and a normal differential. A roentgenogram of the chest revealed pulmonary congestion with slight prominence of the pulmonary conus. Chest fluoroscopy revealed left atrial prominence with posterior displacement of the esophagus. These findings were considered indicative of mitral stenosis without demonstrable mitral insufficiency. An electrocardiogram revealed atrial fibrillation at the rate of 100 per minute and digitalis effect.

The patient was treated for failure, quininidized, and prepared for surgery. On Oct. 29, 1953, a mitral commissurotomy was performed. At surgery there were no detectable thrombi in the atrial cavity or appendage. The mitral orifice would not permit introduction of the tip of the index finger. The fused cusps were fractured and surgery was otherwise uneventful. Microscopic examination of the left atrial appendage removed at surgery revealed no fibrosis or Aschoff's bodies. No rheumatic activity was detectable in the sections. For four days following surgery a mitral diastolic murmur was not detectable. However, on the fifth postoperative day a mitral diastolic murmur, grade II, was discernible. The postoperative course was otherwise uneventful until the seventh postoperative day when the patient suddenly developed pain in the left lower lumbar region and back and numbness in both feet. Examination at this time revealed a marked bradycardia of forty per minute and absence of femoral pulsations. The diagnosis of saddle embolus to the bifurcation of the aorta was established and an aortic embolectomy was performed immediately. Following embolectomy, pulsations returned to both lower extremities and the bradycardia disappeared. It was also noted that the mitral diastolic murmur had again disappeared. Subsequently, the postoperative course was uneventful and the patient was maintained on anticoagulants throughout. She was dismissed from the hospital on Nov. 19, 1953.

Three weeks later, during convalescence, she developed severe pneumonia with temperature up to 104° F., cough, and expectoration of bloody sputum. This responded to penicillin and bed rest. Following recovery from the pneumonia, she noted a recurrence of dyspnea on exertion, rapid heart rate, cough, and orthopnea. She also noted weakness, exhaustion, a slight elevation of the evening temperature, and severe arthralgia in both ankles and knees. It was realized that this patient was suffering from a recurrence of active rheumatic fever, and she was kept at bed rest on a course of salicylates, digitalis, and prophylactic penicillin. She remained at bed rest and semibed rest for nine months and was becoming ambulatory in October, 1954. At this time her pulse was 90 to 100 per minute and irregular, blood pressure 100/70, and no diastolic mitral murmur could be heard. However, a faint grade I aortic diastolic murmur was still discernible in the aortic secondary area. At the present time, this patient is recovering and will probably return to work soon. She is being maintained on prophylactic penicillin.

In summary, this patient experienced rather mild symptoms of an unrecognized acute rheumatic fever during childhood which resulted in mitral and aortic stenosis. Subsequently, she developed three acute episodes of congestive heart failure and atrial fibrillation; two episodes of cerebral embolism; and, eventually, intractable heart failure. A mitral commissurotomy was performed. During the postoperative course, a thromboembolus was thrown to the bifurcation of the aorta. She underwent a successful and uneventful aortic embolectomy. Subsequently, following a severe bout of lobar pneumonia, she developed reactivation of her rheumatic fever. This has responded to bed rest, salicylates, and prophylactic penicillin. Since the mitral obstruction has been removed surgically and reactivations of rheumatic fever can probably be prevented with prophylactic penicillin, the prognosis for this patient is fairly good.

DISCUSSION

In seven previously described cases aortic embolism occurred within a few hours after commissurotomy, probably resulting from dislodgment of a thrombus during operative manipulation. The case reported here of aortic

embolism, following mitral commissurotomy, is believed to be the eighth successfully treated by aortic embolectomy. This case is of further interest because of the occurrence of embolism on the seventh postoperative day which suggests the development of a thrombus postoperatively, either at the split edges of the mitral valve or at the suture line in the fibrillating atrium.

This mechanism of occurrence is substantiated by the following clinical observations. There was complete absence of the preoperative mitral diastolic murmur for the first four postoperative days. On the fifth postoperative day, a grade II apical diastolic murmur was noted. This observation led us to suspect the occurrence of a thrombus partially obstructing the mitral orifice. On the seventh postoperative day, the patient suddenly developed the classical clinical features of aortic saddle embolism and the diastolic murmur again disappeared, providing evidence of dislodgment of the obstruction at the mitral valve.

The fact that intracardiac thrombosis may obstruct the mitral valve and produce the murmur clinically associated with mitral stenosis is well documented in the literature. Schwartz and Biloon[12] in 1931 called attention to the clinical signs of occluding thrombi of the left auricle. In 1935, Kaplan and Hollingsworth[5] reported the case of a 38-year-old man with auricular fibrillation and signs of failure who presented the classical diastolic murmur and presystolic thrill of mitral stenosis. At autopsy the mitral valve was dilated, but was obstructed by a pedunculated auricular thrombus. Nanson and Walker[10] in 1952 reported the occurrence of a thrombus in the left auricle simulating mitral stenosis. This patient underwent surgery but died postoperatively from a cerebrovascular accident. Autopsy revealed a partially organized thrombus attached to the wall of the left atrium in such a way as to occlude the mitral orifice and hence produce a diastolic murmur. No significant degree of mitral stenosis was found.

The occurrence of a partially obstructing thrombus at the edge of the split mitral valve or at the suture line in the left atrium postoperatively may be more frequent than is realized. It is a well-known fact that frequently following what the surgeon believes to be a complete or nearly complete commissurotomy, the cardiologist continues to hear an apical diastolic murmur of reduced intensity. Since this is rarely listened for during the first few postoperative days, while the original surgical dressing is intact, sufficient time elapses for a nonobstructed murmurless valve to become partially obstructed again by thrombus. The complete disappearance of the diastolic thrill over the left ventricle, as determined by the surgeon upon the completion of the commissurotomy, indicates sufficient opening of the mitral valve and also suggests the improbability of one being able to hear a murmur upon auscultation.

It is true, of course, that a good many valves, while opened sufficiently to result in clinical improvement, are not opened completely because of the undesirability of increasing the degree of mitral regurgitation, and a diastolic murmur of reduced intensity is therefore expected. Nevertheless, in those patients who have disappearance of the palpable diastolic ventricular thrill at

surgery and absence of the murmur immediately postoperatively, the appearance of a diastolic murmur later may indicate partial reobstruction of the mitral orifice by intracardiac thrombosis.

Organization of such a thrombus would secure its attachment and obviate the danger of embolism but would ensure permanency of the partial reobstruction of the mitral orifice. Glover,[4] in a recent publication, stated that only five instances of recurrence of stenosis after commissurotomy have been reported and that a critical scrutiny of these suggests the probability that, in reality, an incomplete operation was performed originally. Furthermore, Glover[4] reported no evidence of restenosis by any mechanism in thirty-one patients autopsied after commissurotomy, and Muller[9] found no evidence of endothelialization or restenosis in two patients who died three weeks and seven months after surgery. Keyes and Lam,[6] however, reported the occurrence, eighteen months postoperatively, of a definite restenosis proved at reoperation, which was followed again by reversal of symptoms.

Although it is not possible to detect by palpation all thrombi in the atrium at the time of exploration, the sequence of events in the presently reported case suggests the formation of a thrombus in the postoperative period. The known tendency for intra-atrial thrombi to form in the presence of fibrillation alone can be expected to increase following the surgical creation of raw and roughened surfaces at the mitral orifice and the site of auricular appendectomy. With these considerations in mind, we feel that it is wise to administer anticoagulants during the immediate postoperative period following mitral valve surgery in patients with atrial fibrillation.

SUMMARY

1. A résumé of the literature reveals the successful performance of aortic embolectomy following mitral commissurotomy with long-term survival to have been reported only seven times.

2. An additional case is described in which mitral commissurotomy was performed with immediate disappearance of the mitral diastolic murmur. On the fifth postoperative day, the murmur was again audible, but disappeared on the seventh postoperative day simultaneously with the occurrence of aortic saddle embolism.

3. It is postulated that this transient murmur was produced by a partial obstruction of the mitral valve by an intra-atrial thrombus developing during the first four postoperative days. A review of pertinent literature partially supports this possibility but is not conclusive.

4. Our experience with this case leads us to believe that the administration of anticoagulants in the postoperative period following mitral valve surgery is advisable in patients with atrial fibrillation.

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INTRATHORACIC GOITERS SITUATED IN THE POSTERIOR ASPECT OF THE SUPERIOR MEDIASTINUM

ALFRED HURWITZ, M.D.,* AND ALAN B. SKORNECK, M.D.,** WEST HAVEN, CONN.

(From the Department of Surgery and Department of Radiology, Veterans Administration Hospital)

INTRATHORACIC goiters situated in the posterior aspect of the superior mediastinum are uncommon in comparison to "plunging" substernal goiters. The substernal goiter arises from the lower pole of the lateral thyroid lobe or from the isthmus. On the other hand, the posteriorly placed goiters are derived from the posterolateral aspects of the gland, as emphasized by Sweet.[2] In his reported series of six cases, he stated that the thoracic approach was mandatory in two patients and preferable in a third, because of the large intrathoracic component of the goiter. The following two patients were successfully treated by removal of the goiters through a transthoracic incision.

CASE REPORT

CASE 1.—L. J., a white man, aged 58 years, was admitted to the hospital on July 15, 1953, with a chief complaint of chronic constipation during the past twelve years. Nineteen years before this admission, the patient had experienced a choking sensation in his throat and was told that he had a goiter. A left partial thyroidectomy was performed. A report obtained from the hospital revealed that the pathologic diagnosis was nontoxic goiter. Following that operation the patient had been taking 1 to 3 Gm. of thyroid extract daily in intermittent courses.

Physical examination revealed an obese man weighing 234 pounds. Diffuse enlargement of the thyroid was noted bilaterally. Blood pressure was 154/100. Pulse rate was 80 per minute. No lid lag or exophthalmos was present. Basal metabolic rate was −15 per cent; serum cholesterol was 220 mg. per cent. Chest roentgenogram revealed the presence of a sharply demarcated mass in the posterior part of the superior mediastinum, displacing the trachea anteriorly and to the right. Barium swallow showed the esophagus to be displaced posteriorly and to the right (Fig. 1, *A* and *B*). The patient was given a test dose of 100 μc of I^{131}. A Geiger counter survey indicated normal uptake over the right side of the neck and isthmus. Over the sternum moderate activity was noted, which was highly suggestive of underlying functional thyroid tissue.

On Aug. 6, 1953, a left thoracotomy was performed through the bed of the fifth rib. The mass encountered was firm, with areas of cystic degeneration, measured 6 by 4 cm., and was enucleated without difficulty (Fig. 1, *C*). An attenuated fatty stalk was attached to the top of the tumor and ascended into the neck behind the left subclavian vessels. The pathologic diagnosis was colloid involutional nodule. The patient was discharged on the eleventh postoperative day, after an uneventful convalescence.

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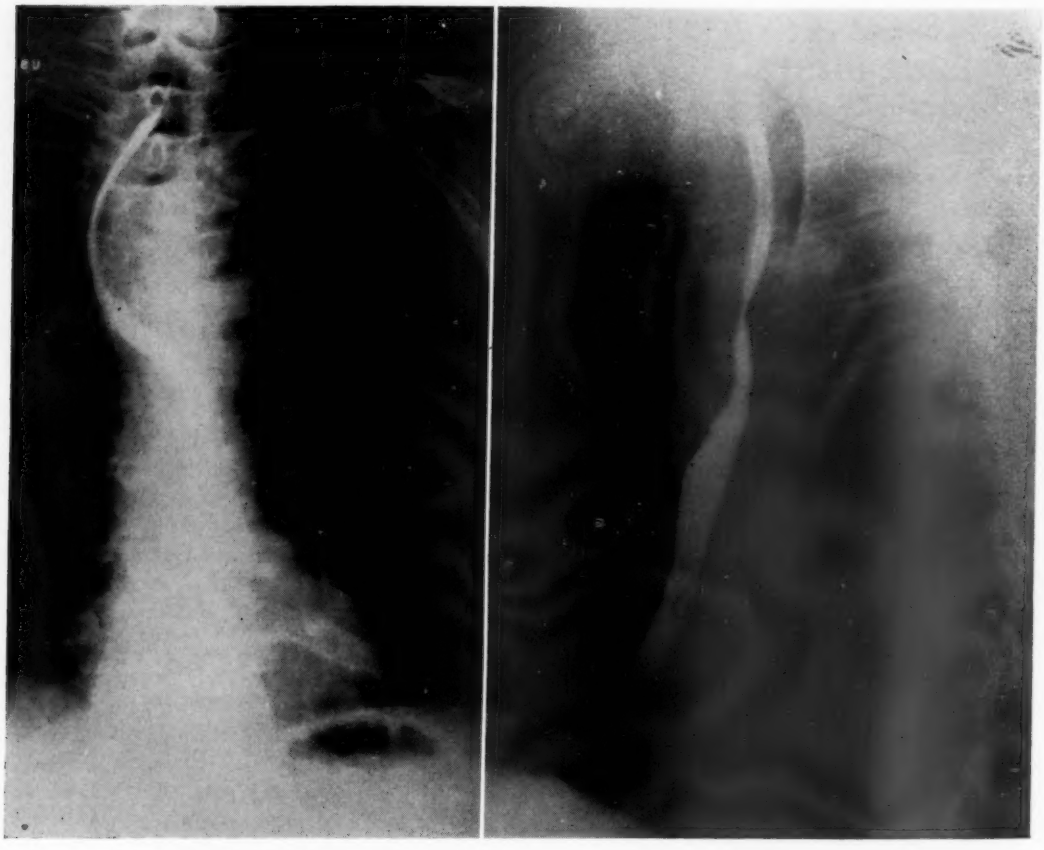
*Formerly Chief of Surgery, Veterans Administration Hospital, West Haven, Conn., and Associate Clinical Professor of Surgery, Yale University School of Medicine; now Professor of Surgery, New York State University School of Medicine, and Chief of Surgery, Maimonides Hospital of Brooklyn, Brooklyn, N. Y.

**Chief of Radiology, Veterans Administration Hospital, West Haven, Conn., and Assistant Clinical Professor of Radiology, Yale University School of Medicine.

CASE 2.—J. A., a 59-year-old white man, was admitted to the West Haven Veterans Administration Hospital on Nov. 18, 1954. His medical history dated back to 1918 when he had been discharged from the Army because of mental disability. Nothing further was known of him until February, 1924, when he was first admitted to a psychiatric hospital with a diagnosis of dementia praecox.

In 1938, during an annual physical examination, enlargement of the right side of the thyroid was noted. No additional work-up was carried out until 1948, at which time radiographic examination revealed the presence of a superior mediastinal mass displacing the trachea to the right. There were no signs of thyrotoxicity or obstruction and the patient was asymptomatic. No laboratory studies were performed.



A. *B.*

Fig. 1.—*A*, The trachea and esophagus are displaced to the right by the mediastinal goiter. *B*, Goiter interposed between the trachea and the esophagus. The trachea is bowed anteriorly. The esophagus is displaced posteriorly and appears somewhat narrowed.

On admission to the West Haven Hospital, physical examination revealed an obese man who was 5 feet, 7 inches tall and weighed 204 pounds. Blood pressure was 120/80. Pulse rate was 80 per minute. The right thyroid lobe was enlarged. During deglutition a firm mass could be felt behind the sternal notch. The trachea was deviated to the right. The heart was not enlarged.

Laboratory work-up showed normal blood counts. Serum cholesterol determination was 242 mg. per cent. A tracer dose of 10 μc of I^{131} was given. At twenty-four hours there was 21.1 per cent uptake over the thyroid gland (low normal) as measured with a scintillation counter. Survey over the thorax revealed no activity beyond the normal body background.

On Feb. 4, 1955, the presence of a large lobulated tumor in the superior mediastinum, interposed between the trachea and esophagus was demonstrated by chest roentgenogram. It was considerably larger than it had been on examination in 1948. The trachea was displaced anteriorly and narrowed. The esophagus was shifted markedly toward the right and posteriorly, and its mucosal folds were ironed out (Fig. 2, *A* and *B*). The mass projected to both sides of the mediastinum but more toward the right. It appeared to be separated from the great vessels and displaced the aorta downward.

Angiocardiography was carried out on March 8. Downward displacement of the aorta and pulmonary vessels was noted and the possibility of aneurysm was eliminated.

C.

Fig. 1 (Cont'd).—*C*, Specimen of intrathoracic goiter showing areas of solid tumor and of cystic degeneration.

On March 28, thoracotomy was performed through the bed of the fifth rib posteriorly after a Levine tube was passed to help delineate the esophagus. A large semifirm mass, measuring 15 by 6 cm., was found lying between the esophagus and trachea (Fig. 2, *C*). A portion of the tumor was cystic and was evacuated. The mass was attached to the thyroid gland in the neck by a 1 cm. stalk.

Pathologic examination revealed this to be a colloid goiter (Fig. 2, *D*).

DISCUSSION

Crohn and Kobak[1] discussed two possible mechanisms which could account for the unusual position of a goiter in the posterior aspect of the mediastinum. One results in an aberrant thyroid completely separated from the cervical gland. This follows failure of fusion of the lateral lobes of the thyroid with

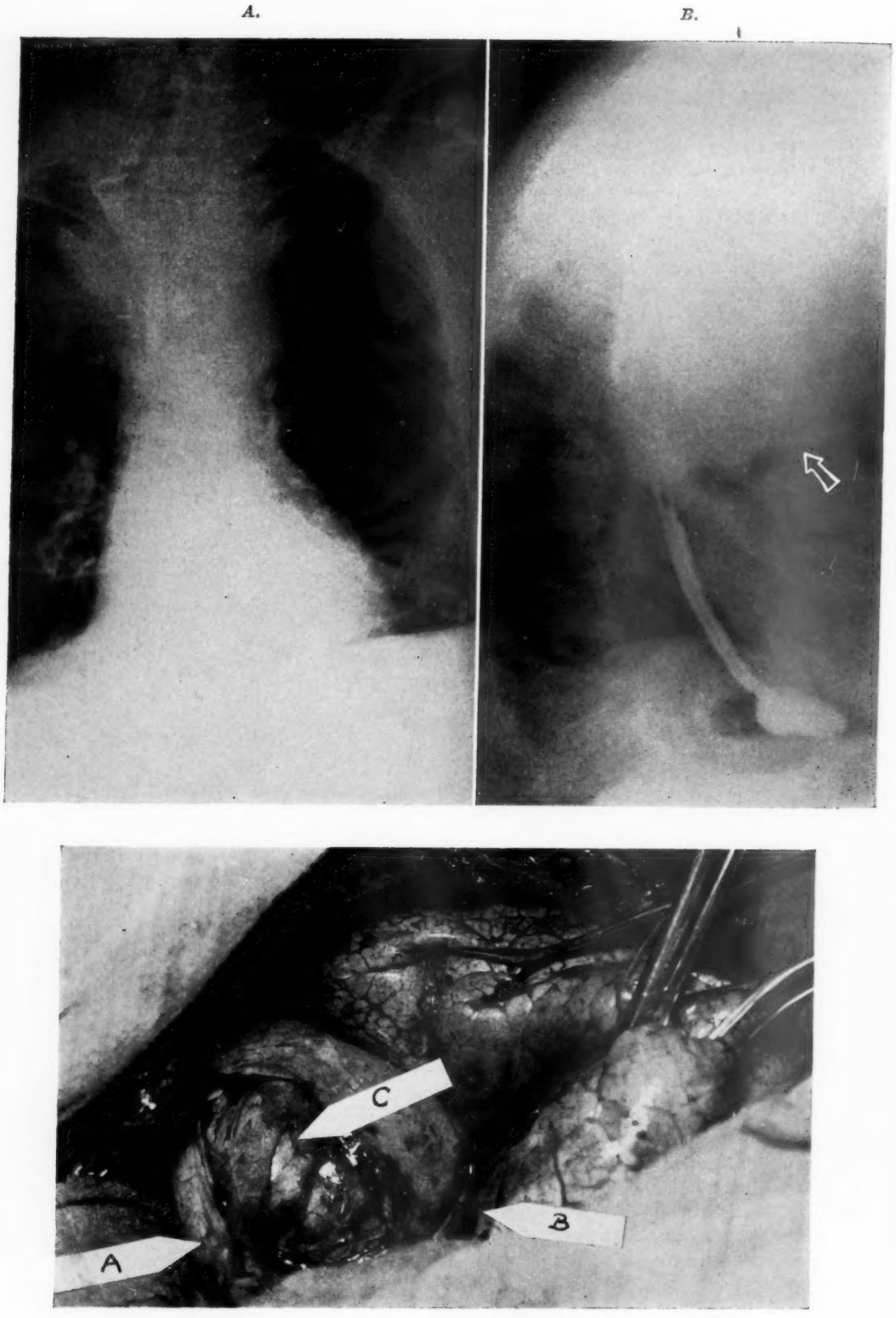


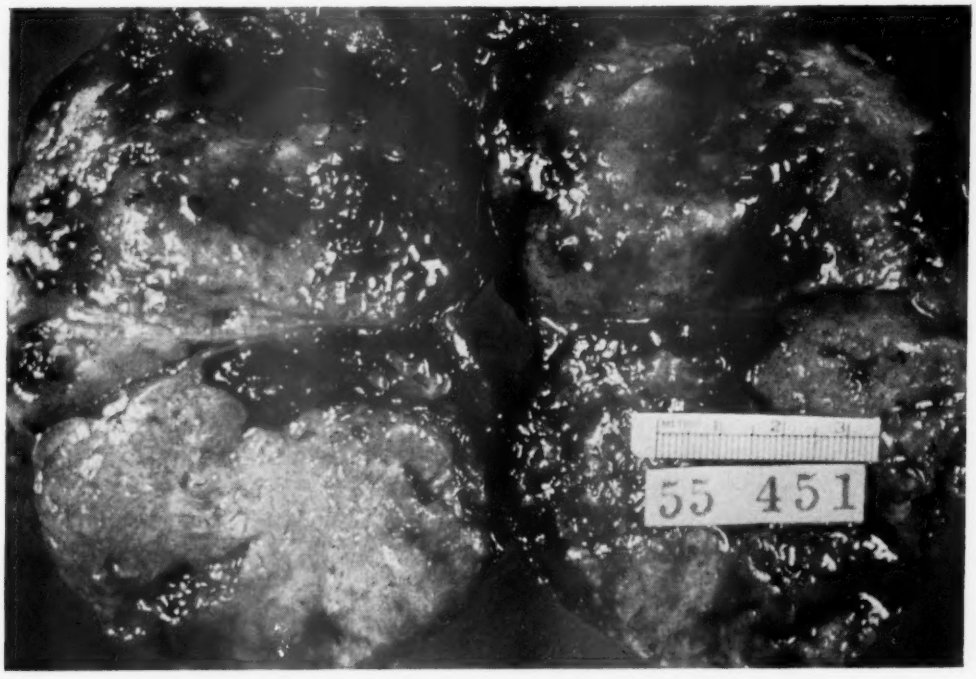
Fig. 2.—*A*, Reveals displacement of the trachea and esophagus to the right by posteriorly placed mediastinal goiter.

B, Thyroid tumor wedged between trachea and esophagus. The trachea is sharply angulated anteriorly (as shown by the arrow) and the esophagus is displaced posteriorly and narrowed.

C, Relationship at surgery. The esophagus (*A*) is sharply displaced posteriorly by the tumor. Sutures are visible around the azygos vein (*B*) which had to be divided to permit removal of the goiter. The mass (*C*) was easily enucleated from esophagus and trachea.

the isthmus in the seventh embryonic week. Fusion normally takes place in the region of the posterior pericardium. If the glandular anlage remains separate, an aberrant thyroid may be found anywhere in the posterior aspect of the mediastinum.

The other mechanism produces "descent" of the thyroid ("plunging" goiter). Because of the continuity of the visceral fascia enclosing the thyroid, trachea, and esophagus in the neck with the visceral fascia in the thorax, a single compartment is formed, along which a goiter may descend. In both of our patients and in all of Sweet's[2] patients, a stalk was found connecting the cervical and thoracic components of the thyroid.



D

Fig. 2 (Cont'd).—*D*, Specimen of posteriorly placed intrathoracic goiter.

Symptoms were lacking in these two patients. Sweet[2] reported that five of his six patients had nonproductive coughs: two patients had moderate dysphagia, and one had moderate dysphonia. Roentgenograms of the chest are most helpful in establishing the diagnosis. These goiters are usually wedged between the esophagus and the trachea. In both of our patients, the trachea was bowed forward and the esophagus displaced posteriorly. Differential diagnoses include teratoid or mesenchymal tumors; enterogenous or bronchial cysts; aneurysm of innominate or aberrant right subclavian artery. Visible extension of the tumor mass downward from the base of the neck would substantiate the diagnosis of intrathoracic goiter. The diagnosis is strengthened by the presence of localized collections of amorphous calcium flecks. Accurate diagnosis may be made by a study of the uptake of radioactive iodine. In the first case, an appreciable uptake of I^{131} by the mediastinal goiter enabled us to make the

diagnosis preoperatively. In the second case, no uptake was noted. This phenomenon could be attributed to the absence of thyroid function due to involutional changes.

Unlike substernal goiters, these posteriorly placed tumors may be impossible to enucleate safely through the cervical approach. In the second case, the mass was so intimately adherent to the azygos vein that this structure was divided to facilitate exposure. Attempts to remove this lesion through a cervical incision might have ended in disaster because of uncontrollable hemorrhage. The passage of a Levine tube preoperatively helps to delineate the esophagus during the operation. These tumors are covered not only by mediastinal pleura, but also by several layers of fascia, all of which should be divided before enucleation of the tumor is attempted. The finding of a narrow, somewhat fatty stalk in both cases suggests that recurrence of this lesion is unlikely.

CONCLUSIONS

Two cases of intrathoracic goiter situated in the posterior superior mediastinum have been reported.

Aids in establishing the preoperative diagnosis have been discussed.

The transthoracic approach was mandatory in both cases.

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SURVIVAL FOLLOWING REMOVAL OF MULTIPLE BRAIN AND LUNG METASTASES FROM TERATOCARCINOMA OF TESTIS

G. E. Moore, M.D., D. M. Perese, M.D., and W. J. Staubitz, M.D.,
Buffalo, N. Y.

(From the Roswell Park Memorial Institute)

THE surgical treatment of metastatic brain tumors is a challenging problem requiring careful appraisal of the general preoperative status of the patient as well as a thorough understanding of the limitations of this type of treatment. Probably the single most important determinant of the period of palliation, and thereby justification for such a procedure, is the biology of the tumor itself. Although several successful reports[6, 8, 9] of long-term survivals in metastatic carcinoma of the brain have been published, this case report is unique since both brain and lung metastases were removed in an attempt to obtain effective palliation.

Fig. 1 summarizes the patient's clinical course.

CASE REPORT

W. S. H., a 29-year-old right-handed truck driver, was admitted on Dec. 8, 1953, for the second time because of persistent headache, drowsiness, nausea, and vomiting of two weeks' duration.

Past History.—His left testicle was removed by the family physician at a local hospital on Sept. 2, 1952, after a six-year period of observation during which time the testicle became hard and doubled in size. Histologic diagnosis of the removed testis was teratocarcinoma containing chorioepitheliomatous elements.

The patient was first seen at Roswell Park Memorial Institute by the Department of Urology on Sept. 22, 1952. Physical examination was negative and there was no local lymph node involvement. On October 11, a retroperitoneal lymph node dissection was carried out. All the removed nodes and spermatic vessels were negative for metastatic lesion. He was discharged from the Institute on Jan. 2, 1953, and was able to return to work. On April 5, 1953 (Fig. 2), a chest film showed the presence of a 2 cm. nodular density in the upper left lung field. He was started on radiation treatment through left anterior and posterior parts receiving a total of 3,000r in a six-week period. There was no decrease in the size of the chest lesion during the following four months.

Second Admission.—Neurological examination on his second admission on Dec. 8, 1953, revealed a semicomatose, markedly debilitated man with right hemiplegia of a spastic type. Eye grounds showed 4-D papilledema. Tests of his visual fields revealed a complete right homonymous hemianopsia. Stretch reflexes were hyperactive and the Babinski reflex was present on the right.

Hospital Course.—A left parieto-occipital craniotomy was performed on December 22, with removal of a well-capsulated, cystic, bullous tumor mass which weighed 194 grams (Fig. 3). His postoperative recovery was surprisingly good. He had regained the use of

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his right arm and leg by the time he was discharged two weeks after the craniotomy. He was clear mentally and walked without assistance. There was no change in the degree of right homonymous hemianopsia.

Third Admission.—The patient was readmitted six weeks later and a left pneumonectomy was performed. Three separate nodules of metastatic teratocarcinoma of both upper and lower lobes were removed. Histologic comparison disclosed that the tumor removed from the brain had a greater degree of undifferentiation and mitosis than the tumor of the lung.

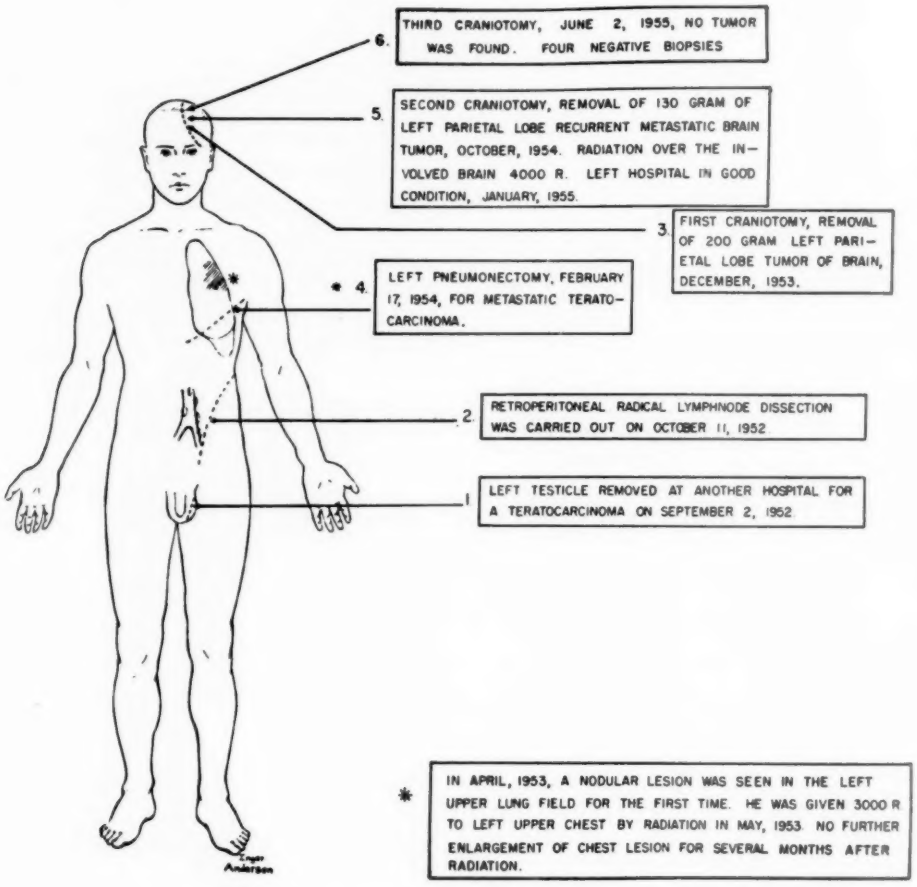
6. THIRD CRANIOTOMY, JUNE 2, 1955, NO TUMOR WAS FOUND. FOUR NEGATIVE BIOPSIES
5. SECOND CRANIOTOMY, REMOVAL OF 130 GRAM OF LEFT PARIETAL LOBE RECURRENT METASTATIC BRAIN TUMOR, OCTOBER, 1954. RADIATION OVER THE INVOLVED BRAIN 4000 R. LEFT HOSPITAL IN GOOD CONDITION, JANUARY, 1955.
3. FIRST CRANIOTOMY, REMOVAL OF 200 GRAM LEFT PARIETAL LOBE TUMOR OF BRAIN, DECEMBER, 1953.
* 4. LEFT PNEUMONECTOMY, FEBRUARY 17, 1954, FOR METASTATIC TERATOCARCINOMA.
2. RETROPERITONEAL RADICAL LYMPHNODE DISSECTION WAS CARRIED OUT ON OCTOBER 11, 1952
1. LEFT TESTICLE REMOVED AT ANOTHER HOSPITAL FOR A TERATOCARCINOMA ON SEPTEMBER 2, 1952
* IN APRIL, 1953, A NODULAR LESION WAS SEEN IN THE LEFT UPPER LUNG FIELD FOR THE FIRST TIME. HE WAS GIVEN 3000 R TO LEFT UPPER CHEST BY RADIATION IN MAY, 1953. NO FURTHER ENLARGEMENT OF CHEST LESION FOR SEVERAL MONTHS AFTER RADIATION.

Fig. 1.—Diagram showing the clinical course of the patient.

Following his discharge on Feb. 20, 1954, he was examined at periodic intervals of six weeks. There was a steady improvement in his general condition although he experienced some dyspnea upon exertion. His physical activities showed definite improvement. He was able to drive his car with safety and participated in various activities at home which included care of the children and general household chores. Our Social Service Department attempted to train him for a job other than truck driving since the persistent right homonymous hemianopsia would hamper his driving ability considerably.

Fourth Admission.—On Sept. 9, 1954, he returned to the Institute after having had three episodes of convulsions during the preceding five weeks. Examination revealed almost the same neurological deficits prior to the first craniotomy, but to a lesser degree. Following diagnostic iodinated human serum albumin brain tumor localization and pneumoencephalogram, he underwent a second craniotomy on October 27. The tumor in the parietal lobe

of the left hemisphere had recurred. This was also a well-capsulated mass (Fig. 4). Its removal was accomplished after peeling it off the surrounding brain in one large piece. Examination of the tumor bed showed several additional saccular capsulated nodules of tumor which were separated from the brain with ease. The tumors weighed 134 grams.

Postoperatively, the patient had a satisfactory recovery with complete improvement of the right-sided weakness and cortical sensory loss. There was no change in the visual field defects of the right homonymous hemianopsia.

Before his discharge he was given a course of x-ray treatment to the left parieto-occipital area of the skull amounting to 4,000 r.

Follow-up examination, seven months after the second craniotomy, revealed that the patient was in good health without weakness, convulsions, or sensory deficit. The defect in his vision remained unchanged.

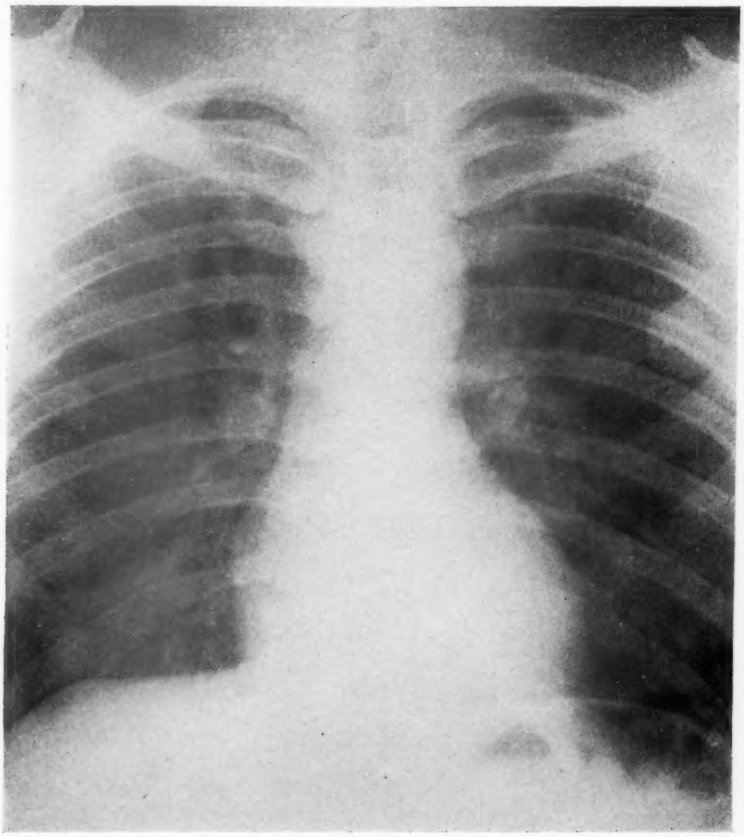

Fig. 2.—Chest roentgenogram of the patient taken in April, 1953, showing a well-rounded mass in upper lobe of the left lung.

Fifth Admission.—On May 18, 1955, he was readmitted to the hospital because of generalized convulsions of two days, and nausea and vomiting of eight days' duration. At this time he was semicomatose but moved all four limbs equally well on command and voluntarily. The eye grounds were normal and no localizing neurological signs were present.

Laboratory studies indicated a severe degree of metabolic alkalosis. As soon as his electrolyte balance was corrected the vomiting decreased in frequency from six to eight times a day to once or twice. He became clear mentally and was able to walk around the ward without assistance. The nonprojectile vomiting persisted, however, requiring careful check-up and replacement of the electrolytes continuously for three weeks. An iodinated

Fig. 3.—First metastatic brain tumor removed in one large piece in December, 1950, weighing 194 grams.

Fig. 4.—One large (134 grams) metastatic tumor mass removed from the left parieto-occipital lobes of the brain following second craniotomy in October, 1954.

human serum albumin brain tumor localization showed a pronounced degree of increased uptake in the left parietal lobe along the anterior edge of the previous craniotomy incision. Although he lacked localizing neurological signs, it was decided to explore the left parietal lobe for the third time.

Left parietal craniotomy on June 2, 1955, revealed no recurrence of tumor. All four biopsy specimens were negative. His postoperative recovery was slow but encouraging. A postoperative pneumoencephalogram showed moderate internal hydrocephalus without any obstruction or displacement. He was discharged to his home on June 22.

When he appeared for a check-up examination three weeks later, his vomiting had ceased and he was eating well. Neurological examination disclosed normal eye grounds, good strength in both limbs, and lively and equal stretch reflexes bilaterally. His right homonymous hemianopsia was unchanged. His chest x-ray showed no evidence of metastases in the right lung.

DISCUSSION

Teratocarcinoma of the testis is frequently seen between the ages of 20 and 40 years. The incidence of five-year survival depends upon the presence of metastases at the time of the administration of treatment. It varies from 11 per cent[2] to 44.4 per cent.[7] A small number of these teratocarcinomas contain chorioepitheliomatous elements.[2, 3] This represents a more malignant growth which often disseminates rapidly, killing the individual within a short time. The spread of metastases to liver, spleen, thyroid, heart, lungs, neck, axilla, and brain is described in the literature by various authors.[4, 8, 10] However, the time interval from the discovery of the testicular tumor until the demise of the patient is not given in every paper discussing various features of these tumors. According to Gray[3] of Mayo Clinic, none of his seven patients with teratocarcinoma containing chorioepitheliomatous elements survived over two years despite immediate orchiectomy and x-ray treatment. Herzog[4] and Schmeel,[8] reporting similar cases at the turn of the century, stated that in their cases the survival time from the appearance of a swelling in the testes until death was less than fifteen weeks. Störtebecker,[10] who published the largest number of neurosurgically treated metastatic brain tumors (158 cases), had one case of teratocarcinoma which was operated upon successfully. Two months later this patient developed signs of recurrent brain tumor. In addition, a lung lesion was also recognized at this time and further neurosurgical intervention was considered inadvisable.

The adherence to this dictum, in general, is a wise one, especially if the surgeon is not sure of the presence of additional lesions in other parts of the brain or body. It is our feeling that every patient with isolated metastatic lesions of the brain deserves an exploratory craniotomy if there is no widespread tumor and the tumor itself is one which is known to remain for long periods of time as an isolated lesion. In our case, the decision to explore this young man was made on the basis of his age (29 years) and the favorable location of the intracranial tumor.

Initially we were not sure that the prolongation of his useful life could be achieved. Since then we have operated upon additional metastatic brain tumors with encouraging results. We were aware of the fact that two-thirds of the metastatic tumors of the brain may be multiple.[10] Conservative treat-

ment offers no hope of prolongation of life in a patient who is hemiplegic, comatose, and has severe papilledema; therefore, the chance of survival should not be denied to him in the presence of isolated brain and lung metastases.

SUMMARY

The treatment of a 29-year-old patient with teratocarcinoma of testes containing chorioepitheliomatous elements with brain and lung metastases is presented. He has lived four years following orchiectomy as a result of radical removal of metastatic brain and lung tumors. The occurrence, prognosis, and merits of the excision of metastatic brain tumors are discussed briefly.

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ADDENDUM

The vomiting noted during the fifth admission was erroneously thought to be associated with a recurrence of the cerebral metastasis and resulted in a negative intracranial exploration. Six weeks later (August, 1955) an isolated jejunal metastasis which was obstructing the bowel was identified and removed. Irradiation was given to the upper right quadrant of the abdomen.

Subsequently the patient has gained 20 pounds and has no disabilities other than a right-sided visual field defect and slight dyspnea on exertion.

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

RESECTION AND ARTERIAL REPLACEMENT IN THE TREATMENT OF POPLITEAL ANEURYSMS

RODMAN E. TABER, M.D., AND MONTAGUE S. LAWRENCE, M.D., IOWA CITY, IOWA

(From the Surgical Service, College of Medicine, State University of Iowa)

RECENT developments in the field of arterial substitution have made available a new approach to the treatment of aneurysmal and occlusive arterial lesions. The application of this form of restorative therapy to the management of patients with popliteal aneurysms constitutes a significant advance over the previous obliterative surgical procedures. A minimal incidence of distal gangrene has followed many of the latter procedures; however, the patient, while being relieved of his aneurysm, has been left with a lower extremity solely dependent upon collateral blood supply for its survival and continued function. The exertional limitations and symptoms incident to popliteal artery obstruction are well recognized.

Arterial aneurysms of the lower extremity occur infrequently, as noted by Mills,[23] who reported a 3.5 per cent incidence in 396 aneurysms seen at the Mayo Clinic. The very significant threat to limb survival following impairment of the principal arterial supply at this level has been well demonstrated. Linton[20] reported that in 22 patients requiring nonelective surgical attack on their popliteal aneurysms, 77 per cent developed gangrene. Five hundred and two battle injuries involving the popliteal artery, reported by DeBakey and Simeone,[5] resulted in distal gangrene in 72.5 per cent of the patients.

The urgent need for instituting surgical therapy in the management of popliteal aneurysms is illustrated by the excellent review of Gifford.[10] Sixty-nine patients having 100 popliteal aneurysms were followed for an average period of fifty months. Of 68 aneurysms managed without surgical therapy, 23, or 33 per cent, developed complications requiring 11 amputations. Among the 100 popliteal aneurysms reviewed by Gifford, 92 were attributed to arteriosclerosis, 3 occurred in patients with syphilis, and 3 were of combined arteriosclerotic and syphilitic origin. Of the remaining 2 aneurysms, 1 was thought to be caused by trauma and the other was of mycotic origin. In this review, 35 of the 100 aneurysms were asymptomatic and only 3 of the patients were aware of their aneurysms prior to examination. The importance of treating

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both symptomatic and asymptomatic aneurysms in this location is born out by Gifford's observation that 121 complications developed from 68 aneurysms which were subjected to nonoperative therapy.

Sporadic reports occur in the literature referring to the so-called "spontaneous cure" of popliteal aneurysms due to occlusive intrasaccular thrombosis. Of the 24 aneurysms which underwent spontaneous thrombosis reported in the series of Gifford,[10] amputation was required in 8 instances, while the remaining 16 patients experienced intermittent claudication. The uncommonly satisfactory end results following intrasaccular thrombosis have also been noted by Shumacker.[25]

The first recorded employment of surgical therapy for the extirpation of an arterial aneurysm is attributed by Ransahoff[24] to Antyllus. Philagrius of Macedon reportedly utilized excisional therapy in the 4th century, and Purmann employed it again in the 17th century.[24] Proximal ligation was successfully employed in 1836 for the treatment of a popliteal aneurysm by Key.[18] An ingenious approach to the problem was made by Thomas Bryant in 1868,[3] who utilized continuous digital pressure for forty-eight hours to effect intrasaccular thrombosis. Medical students at Guy's Hospital alternated at one hour intervals to maintain continuous occlusive compression in a patient with bilateral popliteal aneurysms. The astounding results reported by Matas[22] in 1920, who recorded the results of endoaneurysmorrhaphy employed in the treatment of 103 popliteal aneurysms, have not been subsequently surpassed. This treatment was carried out with a morality of 0.6 per cent and a 5.2 per cent incidence of distal gangrene.

Obliterative or excisional methods of dealing with popliteal aneurysms require careful and extensive preoperative evaluation of the collateral blood supply. The Moskowicz or Matas reactive hyperemia test has been widely and satisfactorily employed for preoperative evaluation of the state of collateral vasculature. Proximal temporary occlusion at the time of operation remains a critical and valuable method of estimating the adequacy of collateral supply. Harley,[13] in 1940, utilized this method, leaving a Crile clamp on the popliteal artery proximal to an aneurysm for a period of 24 hours prior to excision of the lesion. Arteriography was employed in 1937 by Fitzwilliams[8] to evaluate collateral supply. We have found this procedure to be of value for this purpose, as well as for demonstrating the patency of major arterial channels distal to the aneurysm. Lumbar sympathectomy carried out prior to direct surgical attack on the aneurysm has been demonstrated to be of significant value as a protective mechanism in the prevention of distal gangrene.[9, 16, 19, 20] Matas[22] has used proximal external compression to demonstrate the likelihood of success with a direct surgical attack as well as to stimulate collateral circulation.

Methods of surgical attack on extremity aneurysms which allow restoration of arterial continuity had their origin in the restorative aneurysmorrhaphy of Matas.[22] Occasional reports have since appeared in the literature attesting to the value of this method of therapy.

A surgical procedure which will permit complete removal of the aneurysm and simultaneously restore arterial continuity is an appealing concept. The pioneering experimental demonstration of satisfactory arterial homotransplantation by Carrel[4] and Guthrie[12] laid the foundation for present-day success in the field of arterial substitution. A reawakening of interest in the field of vascular substitution by Blakemore[1] was followed by the development of satisfactory vascular homotransplant storage methods by Hufnagle,[15] Gross,[11]

Fig. 1.—Case 1. Showing the bilateral bayonet type incisions employed for resection of the popliteal aneurysms and arterial replacement.

and Marrangonni and Cecchini.[21] The clinical utilization of arterial substitution by Gross,[11] Brown,[2] Dubost,[7] DeBakey,[6] and Julian[17] has adequately demonstrated the feasibility and usefulness of arterial homotransplantation. Our own experiences with the utilization of freeze-dried arterial homotransplants in a wide variety of aortic and peripheral vascular lesions have proved equally satisfactory.[26]

Two patients are presented to demonstrate the satisfactory employment of arterial homotransplantation in the surgical treatment of popliteal aneurysms.

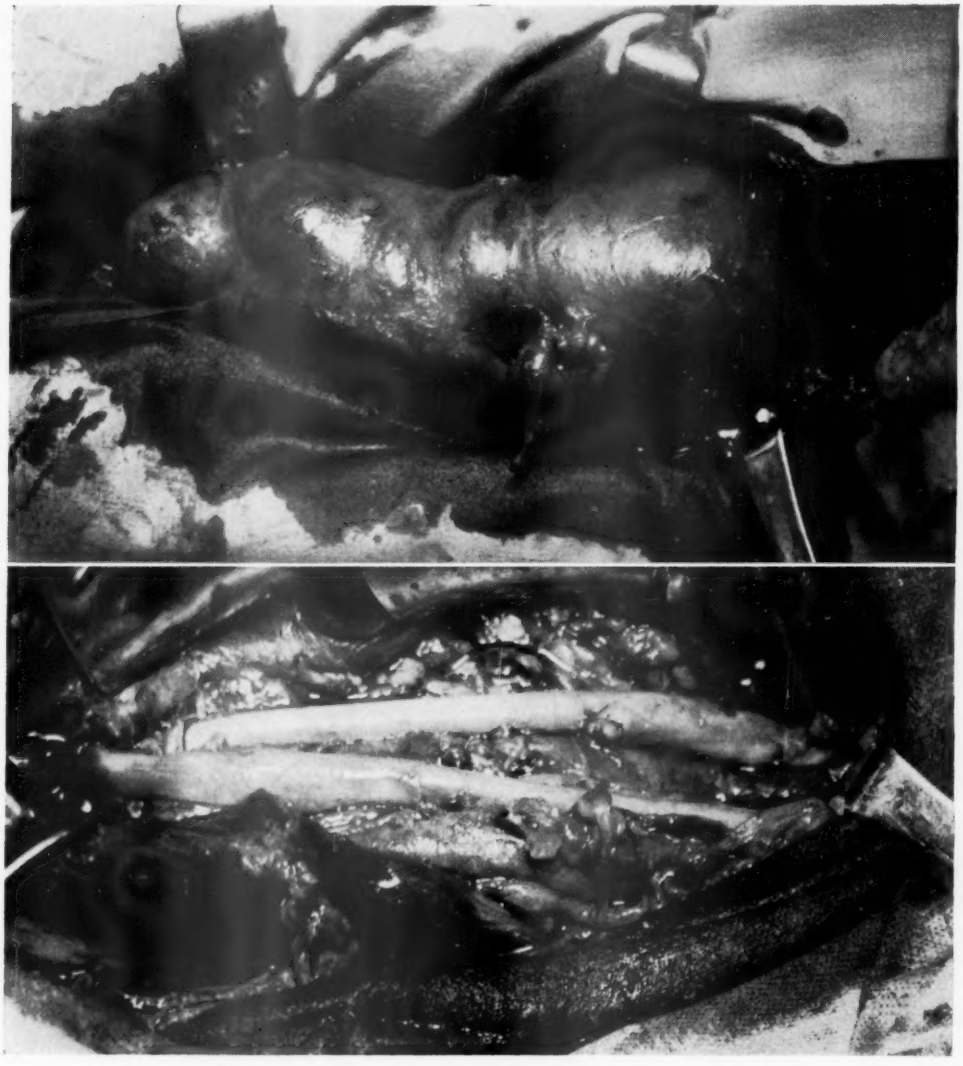
CASE 1.—C. P., 54-12514, a 70-year-old farmer, was admitted to the University Hospitals on Oct. 15, 1954. He had noted pulsating and enlarging masses in both popliteal spaces for 2 and one-half years. The one on the right side had become increasingly painful in the past four weeks. He recalled that the masses became apparent six months following trauma to these areas. This was incurred by riding a tractor in such a manner that the metal seat repeatedly bruised the popliteal regions of both legs. Auricular fibrillation and mild diabetes mellitus were present. He was normotensive and the Cline test was negative. A

Fig. 2.—Operative right femoral arteriogram in Case 1. The visualized lumen of the popliteal aneurysm is small, the remainder of the mass being occupied by circumferential intraulminal thrombosis.

modified Matas compression test of both femoral arteries revealed a distal flush within one minute bilaterally. No pulses were palpable beyond the popliteal regions, and the patient had experienced bilateral exertional claudications for several months. On Oct. 21, 1954, the right popliteal aneurysm was exposed through a bayonet type incision (See Fig. 1). Operative arteriography was carried out through the superficial femoral artery in the thigh

(See Fig. 2). A 20 by 8 by 8 cm. aneurysm was resected and replaced by a 10 cm. freeze-dried arterial homotransplant of appropriate diameter which had been stored for seven months. A continuous everting mattress suture of 5-0 arterial silk was used (See Fig. 3). No difficulty with the distal arterial supply was encountered and the patient was discharged on his 19th postoperative day. Pathologic examination of the aneurysm indicated that it was probably of traumatic and arteriosclerotic origin. Following convalescence, the patient

A.



B.

Fig. 3.—Case 1. *A*, The aneurysm has been isolated and traction tapes placed about the right popliteal artery proximal and distal to this site. *B*, The aneurysm has been resected and replaced by a 10 cm. segment of reconstituted, freeze-dried, arterial homotransplant. The transplant lies above the vein.

returned for resection of the left popliteal aneurysm, which was carried out on Feb. 28, 1955. A 5 by 10 cm. aneurysm was resected and continuity restored using a 7 cm. segment of freeze-dried arterial homotransplant which had been stored for four months. Arteriography

was carried out on the right side at this time, demonstrating patency of the transplant and distal arterial tree (See Fig. 4). Convalescence was uneventful, followed by discharge on the 18th postoperative day. A recurrent left inguinal hernia was repaired during convalescence. Follow-up examination has shown no further complaints referable to the lower extremities.

Fig. 4.—Case 1. Four months postoperative right femoral arteriogram demonstrating the patent popliteal arterial homotransplant.

CASE 2.—J. W., 55-578, a 58-year-old farmer and coal miner, was admitted to the University Hospitals on Jan. 14, 1955. He had noted a pulsating mass in the left popliteal space for four months. Exertional calf pain was present for three months. Twenty-four hours prior to admission this mass was aspirated and explored surgically in another hospital

Fig. 5.—Case 2. A left femoral arteriogram performed 3 months postoperatively following resection and replacement of a popliteal aneurysm. A block of the posterior tibial artery can be seen 1 cm. distal to its origin. This obstruction was noted in an arteriogram performed at the time of operation.

with a tentative diagnosis of Baker's cyst. Massive hemorrhage ensued, and the patient was transferred to University Hospitals following control of the bleeding by direct suture. The left foot was cold, mottled, and pulseless on admission. He was taken to the operating room, where femoral arteriography revealed a complete popliteal artery occlusion. Arterio-

grams distally revealed a patent vascular system. A 10 by 5 by 5 cm. popliteal aneurysm was resected, and arterial continuity restored using a freeze-dried homotransplant which had been stored for 2 and one-half months.

Postoperatively, the circulation to the left lower extremity improved. Ligation of the left superficial femoral vein was carried out because of phlebothrombosis during convalescence. The patient was discharged on the 15th postoperative day. A recent femoral arteriogram reveals a patent popliteal artery (See Fig. 5).

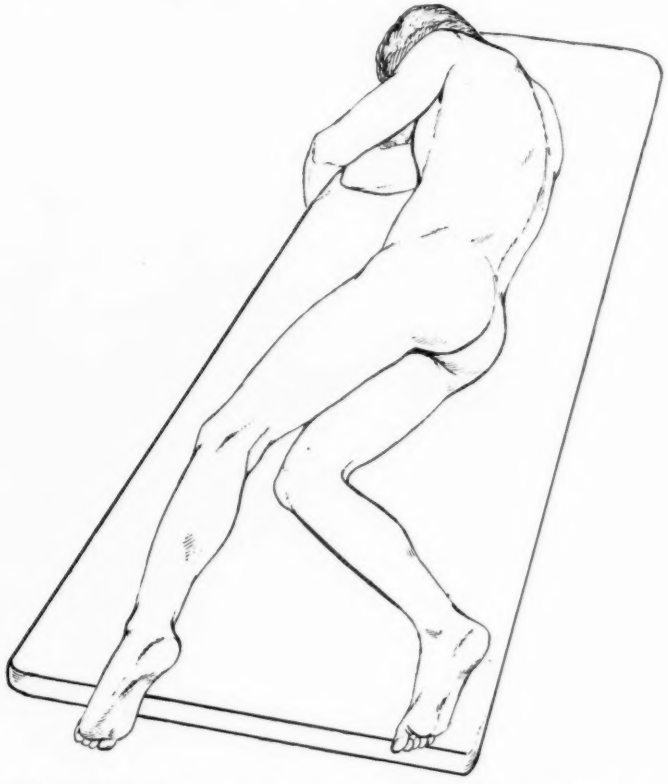


Fig. 6.—Operative position used in the reported cases. Access to the popliteal fossa may be enhanced by tilting the table. The flank is exposed for lumbar sympathectomy if indicated.

DISCUSSION

The operative technique used in the management of these two patients has been similar. The patients were placed in a semi-lateral decubitus position in order that the operated leg could be externally rotated for the performance of femoral arteriography and internally rotated for exposure of the popliteal region (See Fig 6). Positioning of the patient with the operated leg up and also with it on the underside has been tried. The former position, in our opinion, affords better popliteal exposure, as well as makes available the ipsilateral flank for performance of lumbar sympathectomy, should this supplemental procedure be deemed advisable. Continuous epidural anesthesia has proved highly satisfactory. Transparent plastic boots of "Saran" film are used to allow visualization of the circulatory state of the nonsterile foot during the procedure. Following proximal and distal control of the popliteal artery, the aneurysm is dissected free of the popliteal vein. Few collateral vessels

have been sacrificed. Heparin is injected intermittently proximal and distal to the atraumatic vascular clamps. Distal arteriography at the time of operation will aid in deciding whether to use an obliterative procedure or arterial substitution. The arterial homotransplants utilized in these patients have been preserved by a freeze-drying procedure which has been described in another publication[26] (See Fig. 7). Thoracic aorta segments from childhood age donors have fulfilled dimensional requirements for the popliteal artery. The vascular anastomoses are carried out using either a continuous or interrupted everting mattress suture of 6-0 arterial silk. Two sutures are used initially to bisect the anastomosis. To minimize the occurrence of suture line thrombosis, it is advisable to release the proximal and distal clamps simultaneously. The wounds have been closed without drainage and the operated leg immobilized for 14 to 21 days with a posterior molded plaster splint. Quadriceps exercises are instituted and continued throughout convalescence. Ambulation with the aid of crutches is encouraged early in the postoperative period.

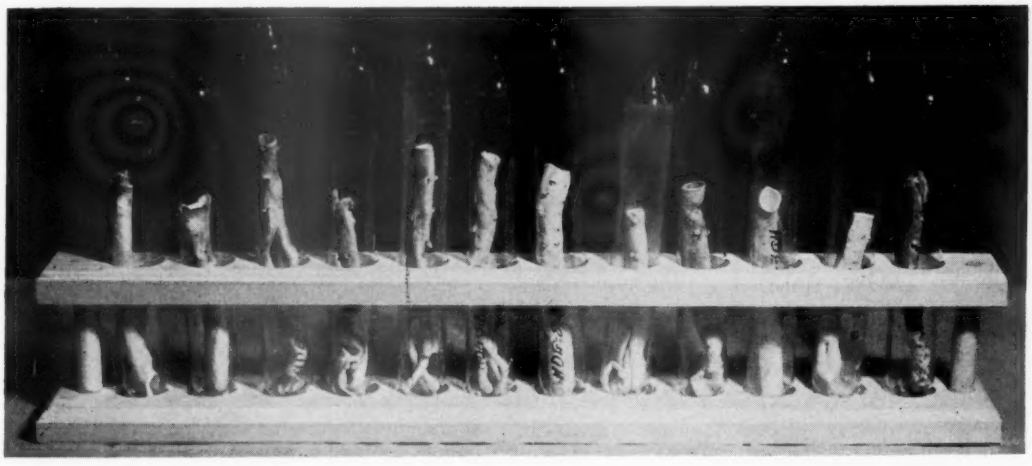


Fig. 7.—Showing freeze-dried arterial homotransplants stored in vacuo.

Although we have had no experience with them, venous autotransplants from the superficial saphenous vein should be useful in this location. Plastic fabric prostheses in their present form would seem undesirable in a flexion area such as the knee joint; however, further developments in the fabrication of these materials may increase their value in this application.

SUMMARY

1. The course and prognosis of popliteal aneurysms as presented in the surgical literature are outlined. Recorded results adequately demonstrate the necessity of instituting surgical therapy in the treatment of both symptomatic and asymptomatic aneurysms in the knee joint region. "Spontaneous cure" or intrasaccular thrombosis rarely results in a satisfactorily functioning extremity. A high incidence of complications, many of which result in distal gangrene,

must be expected when nonsurgical treatment is employed in the management of these lesions. The important developments in the evolution of the treatment of popliteal aneurysms have been outlined.

2. Arterial substitution, allowing restoration of arterial flow, has been successfully applied in the operative management of two patients with three popliteal aneurysms. Freeze-dried arterial homotransplants were utilized. The case reports described pre- and postoperative arteriographic studies. Operative management is discussed.

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ADDENDUM

Since submission of this manuscript a third patient with a popliteal aneurysm has been managed successfully by employment of the procedure outlined in the text.

Editorials

There Is No Substitute for Surgical Judgment

The factor of surgical judgment comes into play at the moment of the first consultation with a patient and lasts until the final severance of the doctor-patient relationship. Surgical judgment differs from surgical skill which implies the quality of technique that, for the most part, is confined to the time a patient actually is undergoing an operation. It is during this period that the quality of judgment should be most dominant over the best of technical skills. This statement is not made with any intent to belittle the value of dexterity but rather to place it in proper perspective.

One does not inherit either judgment or skill. They are attained in varying degrees by individual effort. Only in the "top flight" surgeon do they approach eventual perfection in balance. Good surgical judgment has its foundation in a knowledge not only of the basic sciences but also of the social sciences and the arts. The rocks on which to build are obtainable in premedical and medical schools. It is what one does with one's time after finishing medical school that determines one's rating in judgment. Some acquire good judgment the hard way, by trial and error, at particular expense, in all senses, to the patient; others acquire it by continuing study of the written word from reliable sources, by association with and observation of those of proved good surgical judgment, and by unending constructive criticism of their own work and experience. There is nothing that will limit one's surgical advancement more abruptly than will a closed mind.

The primary surgical approach to a patient in my teaching is, "Can I justifiably get this person out of having an operation, not into having one?"

The surgeon whom I would select to tend my family or me must first know when not to cut, then when and where to cut, how to cut, and when to stop cutting.

—*Charles W. Mayo*

Let Us Not Abet the Carnage

Most physicians and surgeons like to think of the profession as properly secure in the esteem of nonprofessional people. This esteem is based upon careful selection of men to enter the medical profession, long and thorough training in normal undergraduate education, and, in a majority of instances, a residency training appropriate to the caliber and type of professional work upon which the man in question has embarked.

In addition to these factors, which tend to entitle a physician to the high regard of his fellow man, is a factor of at least equal importance and more

fundamental nature. This is the integrity with which he applies the Golden Rule in his day-to-day existence. There are, unfortunately, among us men to whom such concepts appear to have little meaning. The argument is frequently heard that it is not important whether the surgeon shares his fee with the referring physician, provided both men are acutely aware of the interests of the patient with whom they are concerned. Human nature, however, appears not to be so constituted as to make this kind of acumen enduring even if at first ostensibly possible.

The tendency among us as surgeons is to use those methods which are available to us to eradicate such fee-splitting in our own ranks, and to eliminate from our councils and hospitals those guilty of this breach of faith with the patient. Those so excluded from our ranks have commonly gravitated toward hospitals outside the pale of the Joint Committee on Accreditation. Commonly, these have been proprietary rather than voluntary hospitals. A second group comes to utilize such institutions, namely, those who find themselves not yet qualified for admission to the staff of approved hospitals.

Institutions which operate in such irregular fashion in general come to be dominated by a small number of surgeons, often only one, two, or three, who commonly resist attempts at reform, both because such reform will curtail their ill-gotten gains, and because they are correctly fearful that reform will reveal a limitation of their qualifications and thus restrict the types of surgical work which they can undertake.

Such institutions, so dominated by ill-trained and ruthless surgeons, are, sad to say, to be found all across our country. The layman has little or no knowledge of the factors mentioned above, and is, therefore, in many areas, likely, on random sampling of physicians, to fall into the hands of men (or institutions) who advise ill-considered or unnecessary operations because of financial gain, and who perform these procedures with less facility and thoroughness than do surgeons with proper training.

Such irregular hospitals rarely hold on their staffs men of genuine prestige. It is not in such fashion, therefore, that they are able to attract the attention and interest of the layman. This end is achieved by certain of them by issuance of invitations to speak at their hospital staff meetings to men of genuine quality and world-wide repute, usually who come from a distance from the hospital in question and are unaware of the status of their hosts. These presentations are well publicized in such fashion that the mind of the uninformed layman comes to associate the name of the hospital with the quality of the speaker. When next an illness arises, the layman quite naturally gravitates to the area which has enjoyed such publicity. Those surgeons who have had the misfortune to work in charity hospitals with such irregular institutions in the neighborhood can appreciate the results of such gravitation in terms of maimed bodies, exsanguinated life savings, squandered chances of salvage, and legion other catastrophes.

Many very worthy approaches to solution of this problem have been made by the American College of Surgeons and the Joint Accreditation Committee

with support from the specialty boards. Three further steps are hereby suggested. First, men of sound academic and professional standing who are invited to speak in institutions or areas with which they are not fully familiar would help the profession to cut this carnage by withholding the luster of their reputations in support of improper institutions. This may readily be accomplished by careful inquiries addressed to reputable physicians in the area of the institution prior to the acceptance of invitations to appear in public. Second, it would be helpful to the innocent public if reputable physicians in the neighborhood of such illicit institutions were to apprise prospective guest speakers of such hospitals of the true nature of the activities within them. Finally, the established ethical members of the profession might avoid much of this trouble by offering a helping hand to struggling younger men of promise toward admission into proper hospital staffs with such expedition as not to push them elsewhere through discouragement.

—*Clarence Dennis*

Appraisal of Progress in Surgical Therapy

CONDUCTED BY WARREN H. COLE, M.D.
ASSISTED BY
J. GARROTT ALLEN, M.D. CLARENCE DENNIS, M.D.

SURGICAL ASPECTS OF JAUNDICE

ROBERT M. ZOLLINGER, M.D., AND ROGER D. WILLIAMS, M.D., COLUMBUS, OHIO
(From the Department of Surgery, College of Medicine, The Ohio State University)

THE surgeon must be concerned not only with improving his diagnostic accuracy but also with factors affecting the surgical risk in jaundiced patients. A survey of the literature leads one to conclude that, despite some improvement in laboratory tests, no simple formula yet exists for establishing the diagnosis in any single jaundiced patient.[1, 2, 6] Several years ago we became concerned about our own accuracy of diagnosis and the need for lowering our surgical morbidity and mortality. An evaluation of 100 consecutive patients at that time[16] showed that an aggressive policy designed to establish a correct diagnosis by history and physical examination while awaiting the results of laboratory tests must be assumed. Eventually both the clinical and laboratory data must be carefully balanced for or against the original diagnosis. More efficient utilization of the laboratory data was apparent if the multiple reports were recorded on a single "Jaundice Balance Sheet" which listed support for intrahepatic jaundice (medical) on one side and support for posthepatic jaundice (surgical) on the opposite side. The development of this policy rather than the dependence upon any particular laboratory test has been re-evaluated in a recent study of another 100 surgical cases plus an additional 100 cases of medical jaundice used for comparison.

Since surgery has little to offer the patient with medical jaundice, each patient presents a unique problem requiring careful evaluation. A practical classification of jaundice is necessary to appreciate the problem of whether or not the patient will benefit from surgery. We have preferred to use the clinical classification of prehepatic, hepatic, and posthepatic jaundice[3] rather than the pathophysiologic approach of Rich.[12] As may be seen in Fig. 1, prehepatic or hemolytic jaundice may or may not be surgical. Since this type of jaundice is rather uncommon and the absence of bile in the urine is rather characteristic, the diagnosis is usually not evasive.

The numerous problems in diagnosis require continued evaluation by every surgeon. The jaundiced patient is usually uncomfortable, unsightly, and

unable to work. He and his family are rightly concerned about an early diagnosis. With an aging population combined with widespread use of serums and needle injections, the impression that jaundice in older people is due either to stone or malignancy is not always substantiated at operation. These factors should not tend to press early surgery with a diagnosis based primarily on laboratory findings. On the other hand, the jaundiced patient may be allowed to remain jaundiced for too long a period of time before complete evaluation is carried out in the hope that jaundice will clear or the diagnosis become obvious. Such a policy permits progressive liver damage which not only further confuses the interpretation of laboratory results but also increases the surgical risk of the patient.

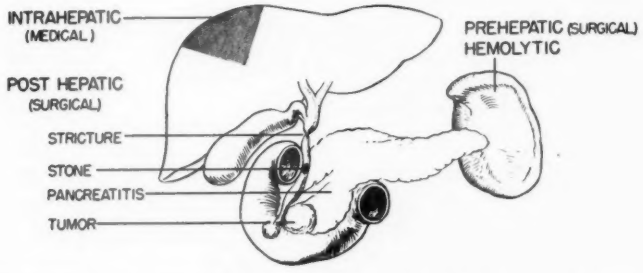

Fig. 1.—Classification of jaundice. Of the three major types of jaundice the most difficulty arises in differentiating intrahepatic (medical) from extrahepatic (surgical) jaundice.

No test or "battery" of tests for jaundice have as yet in our opinion invalidated the necessity of a careful history and meticulous physical examination. One becomes impressed with this fact when observing the diagnostic results of the older, experienced clinician who relies on history and physical examination compared to those of the young man who depends more upon the laboratory for diagnosis. Only when the laboratory tests are evaluated in the light of the duration and intensity of jaundice and all factors are weighed for and against the differential of medical versus surgical jaundice are they of specific value. These tests determine liver function at the time performed, and while some are effected by obstruction and others more by the degree of hepatocellular damage, none is necessarily diagnostic in the individual patient. Since liver damage is usually progressive with continued jaundice, delay of these tests should be avoided. Laboratory tests are of most value when carefully selected, performed early and, in some cases, repeated. Mild jaundice shortly following typical biliary colic will not require the same clinical concern or number of tests as might be needed in the patient with silent jaundice of several weeks' duration.

HISTORY

An accurate history remains the most important factor in establishing a correct diagnosis in the jaundiced patient. Information about previous biliary tract surgery or operations for malignancy elsewhere, or a history of alcoholism, association with hepatotoxic agents, or endemic disease must be obtained for obvious reasons. Sex distribution has been stated to be nearly equal in patients

with hepatitis whereas common duct stones are more common in women and malignant biliary obstruction more common in men.[8] We have not found a significant difference in our own cases. In our series of 300 patients, 200 of whom had surgical jaundice and 100, hepatocellular disease, over two-thirds of the patients with biliary obstruction were over the age of 50 years, while nearly the same percentage of those with medical jaundice were under 50 years (Fig. 2). For some reason, perhaps a difference of symptoms or less concern over them, the older patient with obstructive jaundice tends to seek hospitalization

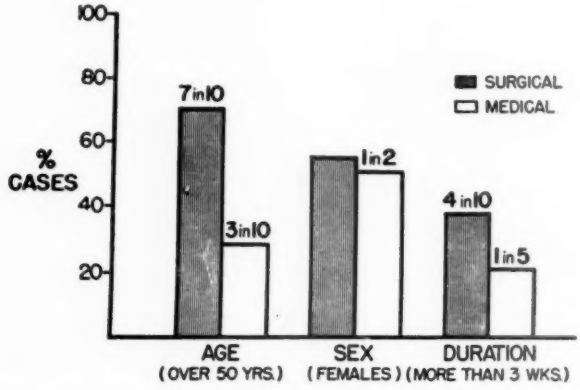

Fig. 2.—Age, sex, and duration of jaundice. Although the great majority of patients with surgical jaundice are over 50 years of age, medical jaundice was rather common in the older age group. Twice as many surgical cases had their jaundice over three weeks before hospitalization.

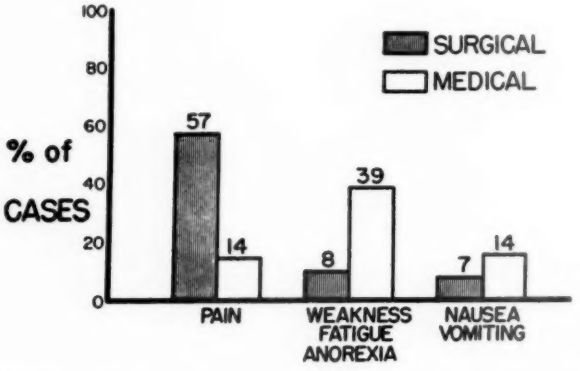

Fig. 3.—First symptom of jaundice (equal frequency of all types). While pain as a first symptom suggests extrahepatic jaundice, weakness and anorexia should suggest intrahepatic (medical) jaundice. Silent jaundice without other symptoms is uncommon regardless of its etiology.

later than those patients with obstructive jaundice seen over three weeks after the onset of jaundice, a factor which may add further confusion to laboratory aids in diagnosis since progressive liver damage will have occurred.

The first symptoms, usually occurring well before the onset of jaundice, must be carefully evaluated, but too often the symptoms of jaundice and its associated discomforts overshadow earlier signs. Pain preceding jaundice both

in benign and malignant obstructive jaundice was four times more common (57 per cent) than in medical jaundice (14 per cent) (Fig. 3). Weakness, fatigue, and anorexia preceded jaundice in eight per cent of these patients, while occurring early in over one-third of our patients with medical jaundice. Nausea and vomiting was twice as common as a first symptom in patients with hepatocellular disease. On the other hand, this symptom, when pronounced, has been noted in 8 out of 10 patients with colic from a common duct stone. Jaundice preceded other symptoms in only a few patients but with equal frequency in both medical and surgical cases.

In an analysis of more prolonged symptoms the type and severity of pain and the occurrence of a significant weight loss are of the most value. Pain was present in 8 out of 10 patients with surgical jaundice of all types and in only one in 5 patients with medical jaundice (Fig. 4).

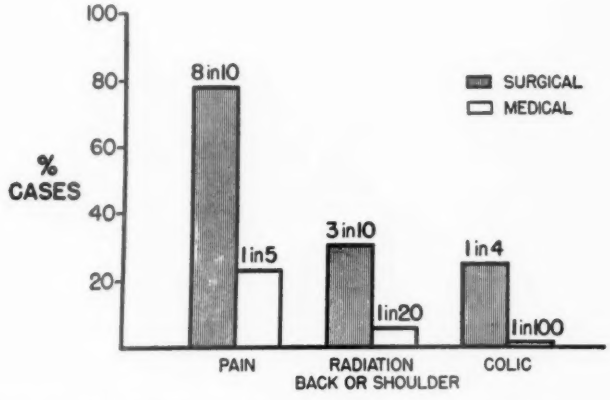

Fig. 4.—Pain of jaundice. Pain, particularly when it is of a colicky type or radiates to the back or shoulder, should suggest extrahepatic obstructive jaundice.

Contrary to older opinion that painless jaundice signifies malignancy, nearly 60 per cent of our patients had pain, often of as great severity as those with benign obstructive jaundice. A difference in location and severity of pain in patients with hepatocellular disease was noted. While radiation to either the back or shoulder occurred in one-fourth of patients with obstructive jaundice, pain radiation was quite uncommon with medical jaundice. On the other hand, weight loss was found in almost every patient with malignancy and half of these patients had lost over 20 pounds. This degree of weight loss was rare with hepatocellular disease and 7 out of 10 of our patients had not lost any significant weight when first seen (Fig. 5). The occurrence of weight loss with common duct stones or stricture is probably due either to the fear of pain from eating or the absence of bile from the gastrointestinal tract. This symptom like all others must be evaluated in terms of the duration of jaundice and other associated symptoms.

The character of jaundice and its association with infection are quite important. Fluctuating jaundice may suggest common duct stones, especially

when associated with moderate to severe attacks of biliary colic. The association of chills and fever not only more strongly support this diagnosis, but over a long period of time may lead to confusing laboratory data since repeated attacks of cholangitis ultimately lead to liver parenchymal injury. Chills and fever, however, are difficult symptoms to evaluate since the history may be inaccurate and the tendency toward routine use of anticolic therapy has undoubtedly reduced the prevalence as well as the significance of this symptom. It occurs in both medical and surgical jaundice with so near equal frequency that this finding has little clinical significance unless considered in the light of pain and weight loss. Again emphasis should be placed on early symptoms since laboratory data will be quite confusing in many cases of obstructive jaundice with cholangitis. It is particularly important to re-evaluate this aspect of the history when considering the laboratory results, since significant liver parenchymal damage occurs very late, even in complete biliary tract obstruction, unless associated with infection in the biliary tract.[10]

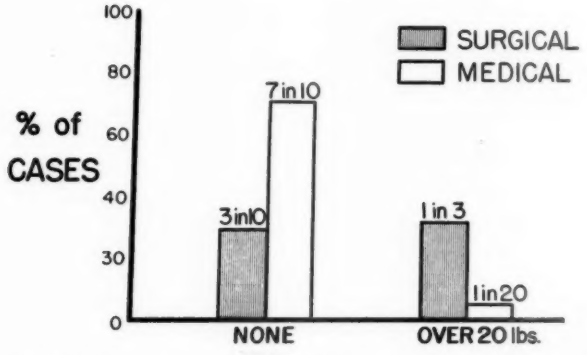

Fig. 5.—Weight loss in jaundice. Significant weight loss in medical jaundice is uncommon. This must be related to the duration and severity of the jaundice.

The occurrence of pruritus during the course of obstructive jaundice is important; however, it may occur in some cases of hepatitis. This is considered due to excessive bile salts in the blood which more commonly occurs in obstructive jaundice; however, obstructive aspects of hepatocellular disease occur both early in severe liver damage or late with prolonged but marked parenchymal destruction. Burning of the conjunctivae alone in the mildly jaundiced patient certainly supports biliary obstruction. Pruritus was noted twice as often in the patients with surgical jaundice as in those with hepatocellular disease.

The character of both the urine and stools must be ascertained. The urine usually becomes dark before clinical jaundice appears since the kidneys are capable of excreting large quantities of bilirubin and urobilinogen. The single test of shaking the urine to assess the presence of bile should not be overlooked. If bile-colored foam does not form, bile is absent and prehepatic jaundice is present. Gray or clay colored stools occurring immediately following progressive jaundice or occurring immediately after periods of pain strongly support surgical or obstructive jaundice. It must be remembered, however, that during

the early stages of severe hepatocellular jaundice an obstructive phase occurs, usually during the first two weeks of the disease, and acholic stools are common (Fig. 6).

Little need be said about the history required to differentiate prehepatic or hemolytic jaundice from other types. If the diagnosis is considered, an adequate history should show in most cases a familial tendency to jaundice. Furthermore, the physical examination demonstrating a large spleen should further suggest this possibility and stimulate a re-evaluation of the history. Once the diagnosis is considered, establishment by separate laboratory determination which shows absence of bile in the urine, reticulocytosis, anemia, and a hyperactive bone marrow is much easier than the differentiation between certain types of obstructive and hepatocellular jaundice.

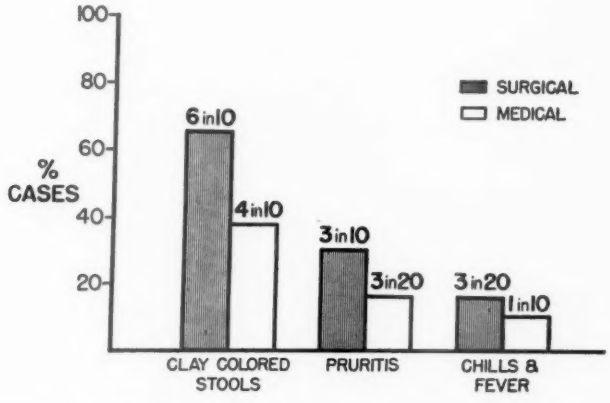

Fig. 6.—Frequency of signs and symptoms of jaundice. These symptoms are of so near equal frequency that they may be of little value unless considered in the light of other factors.

PHYSICAL EXAMINATION

Too often a relatively easy diagnosis in the jaundiced patient is missed by failure to do a thorough physical examination. Unfortunately, several of the pertinent physical findings typical of either medical or surgical jaundice are so dependent upon the duration and severity of jaundice that their critical evaluation from the standpoint of frequency of occurrence is difficult. While an enlarged liver early in the course of jaundice strongly suggests hepatocellular disease, it is usually enlarged after a few weeks in most types of jaundice. The intense greenish-yellow skin of obstructive jaundice has been contrasted with the canary yellow of hepatocellular disease. Such a contrast is not possible in the mildly jaundiced patient.

There are, however, several physical findings worthy of note. A grossly nodular liver, particularly in the patient with significant weight loss, implies metastatic carcinoma. An enlarged spleen supports the diagnosis of either prehepatic icterus due to hemolytic anemia or hepatocellular disease since splenomegaly is rare in obstructive jaundice unless jaundice has been present several months. A distended gall bladder is most often found in biliary obstruc-

tion due to malignancy; however, in our experience the difficulty of differentiating gall bladder from liver has been noted, particularly when tenderness exists. When Courvoisier's Law is considered in the jaundiced patient it must be remembered that acute obstruction due to stone occasionally occurs and presents a large tender gall bladder. For this reason a history of previous attacks of pain, chills, or fever must be considered. Spider angiomata and decreased hair on the trunk both suggest hepatocellular disease, particularly cirrhosis, when observed. Our evaluated series of patients with cirrhosis is too small to suggest their frequency. Finally, ascites, when present, often points to cirrhosis or far-advanced carcinomatous obstructive jaundice.

LABORATORY DATA

Only after a thorough history and physical examination have suggested the diagnosis should carefully selected laboratory data be used to confirm the clinical impression. These tests can be divided into those suggesting medical jaundice and those suggesting obstructive or surgical jaundice; but each has its greatest value only when considered in the light of all other findings. Generally an elevated cephalin flocculation and thymol turbidity or a decreased prothrombin or serum albumin suggest hepatocellular disease. An elevated alkaline phosphatase or serum cholesterol more strongly suggest obstructive jaundice.

More recently the introduction of serum mucoprotein determinations has somewhat improved diagnosis in our hands.[4] This improvement may have been due to a more serious consideration of the problems in jaundice rather than to the test per se. However, serum mucoprotein determinations have been found to be relatively cheap and simple to perform and their values are quite consistent. When malignancy and infection are considered in the individual patient this test is certainly as helpful as any single laboratory test. Normal values have been found to range between 40 and 70 mg. per 100 c.c. Elevations are produced by both tissue destruction and regeneration, but hepatocellular disease leads to a low value due to inability of the liver to produce this polysaccharide. We have found that when the value is below 40 mg. per cent, medical jaundice is almost invariably present.

Unfortunately, since intrahepatic biliary obstruction occurs not infrequently with hepatitis[11] and hepatocellular damage occurs with prolonged biliary obstruction no laboratory test can be relied upon in the individual patient as a diagnostic crutch. This does not mean that a large number of tests must be used in order to have a more thorough evaluation of the patient. As a matter of fact, there are only two or three tests which are of real value in the differential diagnosis in most jaundiced patients. These include the alkaline phosphatase, cephalin flocculation (or thymol turbidity), and perhaps the serum mucoprotein. An elevated alkaline phosphatase suggests obstruction while most other liver function tests suggest the degree of hepatocellular damage. We may obtain other tests in the severely jaundiced poor risk patient, but they have been either of no value or they are of use in estimating the prognosis rather than in confirming the diagnosis.

Those tests of little or no value in medical versus surgical jaundice include the Van den Bergh reaction and the determination of urine and stool urobilinogen. The Van den Bergh reaction may be used to assess the degree of jaundice, a factor fairly well determined clinically, but it is of value only in patients with prehepatic or hemolytic jaundice where the indirect fraction alone is elevated. Regardless of the etiology of other types of jaundice, no significant differences were noted between medical and surgical cases with jaundice of comparable intensity. The stool and urine urobilinogen values have been most irregular in our hands in both types of jaundice. This may be due to incomplete obstruction, the change of bilirubin to urobilinogen by reducing bacteria in a contaminated 24-hour sample, or failure to take into consideration that the patient was on a wide spectrum antibiotic which, by reducing intestinal flora, decreases urobilinogen formation.[7]

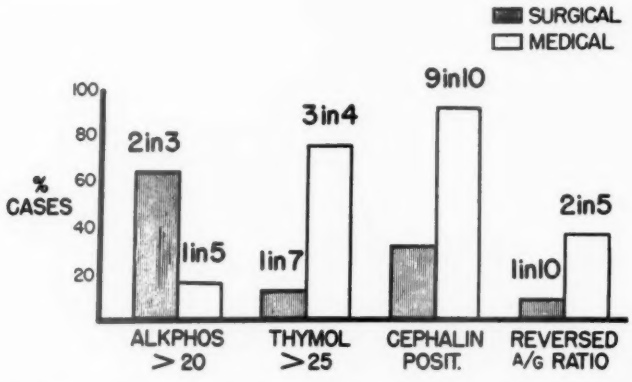

Fig. 7.—Laboratory findings in jaundice. Although certain tests support surgical and others support medical jaundice, only the alkaline phosphatase and either the cephalin flocculation or the thymol turbidity are needed to aid in the diagnosis of most cases.

In poor risk patients in whom surgery is considered, a more complete battery of laboratory studies will be of some help. These tests determining the per cent of cholesterol esters, response of prothrombin to vitamin K, and the total protein and albumin-globulin ratio will further establish the degree of liver damage but are of most importance in assessing the surgical risk and prognosis which will be discussed later.

We have attempted to evaluate our own laboratory results with as great a disappointment as others. While an alkaline phosphatase of over twenty occurred in over one-half of the patients with obstructive jaundice, it was found in 1 out of 8 patients with medical jaundice (Fig. 7). Reliance on the accuracy of this test in diagnosis in two patients with a phosphatase level of over 40 Bodansky units led to errors and laparotomy in two patients. The cephalin flocculation and thymol turbidity results were of equal value. A thymol of over 25 units and a positive cephalin were noted in from 75 to 89 per cent of the cases of medical jaundice and in only 14 to 33 per cent of those with surgical jaundice. A reversed albumin-globulin ratio was seen 4 times as often in medical as in surgical jaundice. Such findings, though statistically significant, are of little value in the individual case unless other factors are considered.

Repeated tests over a short period of time have been considered of great value but probably only increase the patient's hospital expenses unless jaundice is deepening. Our repeated tests show that hepatocellular damage and obstructive laboratory findings may proceed or recede during the time of observation regardless of the etiology of jaundice. Of practical value, however, is the fact that if the severity of jaundice is progressing, a significant decrease of liver function will be noted only with medical jaundice.

We have always considered the duration and severity of jaundice of particular importance in an evaluation of all laboratory data. When the results of several tests are considered either in mild or severe jaundice of less than one month's duration the diagnosis seemed clinically easier than in those patients with long-standing jaundice. However, when values for alkaline phosphatase, cephalin flocculation, thymol turbidity and a reversed albumin-globulin ratio in medical and surgical jaundice are compared in the patients jaundiced less

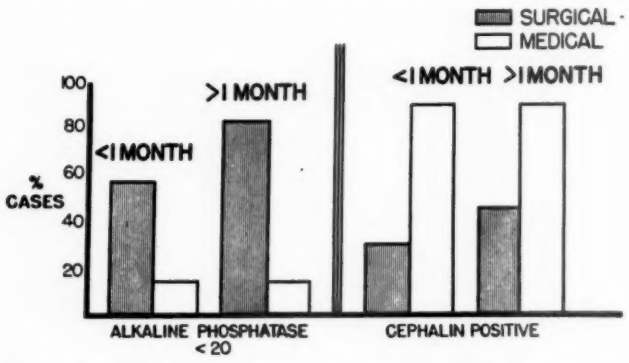

Fig. 8.—Duration of jaundice vs. laboratory findings. While the per cent of patients with a high alkaline phosphatase increases with the duration of jaundice, the same small percentage have an elevated alkaline phosphatase regardless of the duration of the jaundice. As liver damage progresses with obstructive jaundice, the incidence of positive cephalin flocculation increases.

than one month with those jaundiced over one month, several interesting features are noted. While the number of patients with obstructive jaundice having an alkaline phosphatase over 20 increases with the duration of jaundice, the same percentage of those with medical jaundice have this obstructive phenomenon regardless of the duration of jaundice (Fig. 8). The incidence of significantly elevated cephalin flocculation and thymol turbidity and of a reversed albumin-globulin ratio rises as jaundice continues regardless of the type. These findings confirm the impression that regardless of the duration of the jaundice at the time the patient is first seen a certain percentage with either medical or surgical jaundice will have both obstructive and hepatocellular laboratory results. It might be possible in a larger series of cases to show that when duration and severity of jaundice are considered together, more practical value can be attached to specific laboratory tests. At the present time it is concluded that no laboratory test alone is of great value without considering other factors in the individual patient. Again we must revert to the use of a balance sheet as an aid to the over-all appraisal of each patient.

JAUNDICE BALANCE SHEET

The utilization of a "balance sheet" such as suggested in Fig. 9 has been found to be of considerable help in the over-all evaluation of each patient with jaundice. The greatest value of such a sheet lies in combining all significant data in one place on the chart. After all data are accumulated, the first clinical

JAUNDICE BALANCE SHEET

Hosp. No. _____ Name _____ Age ____ Sex ____ Race _____

Original Diagnosis _____ Date _____ Signature _____
(Based on History & P.E.)

Final Working Diagnosis _____ Date _____ Signature _____

RELATE

DURATION: ____ Days ____ Weeks ____ Months

SEVERITY: Deep ( ) Mild ( )

CHARACTER: Fluctuating ( ) Constant ( )
Progressive ( )

MEDICAL	TO	SURGICAL
	History *	
_____	Pain - constant ( ), colic ( ), radiation ( )	_____
_____	Anorexia - food intolerance ( )	_____
_____	Weight Loss (lbs.)	_____
_____	Transfusions ( ), Injections ( )	_____
_____	Pruritus ( )	_____
	Physical Examination *	
_____	Liver Palpable ( ), Tender ( ), Nodular ( )	_____
_____	Spleen Palpable ( )	_____
_____	Gallbladder Palpable ( )	_____
_____	Skin - spiders ( ), varices ( )	_____
	Laboratory Findings ●	
_____	X-ray - tumors ( ), gallstones ( )	_____
_____	Alkaline phosphatase ( )	_____
_____	Cephalin ( )	_____
_____	Thymol ( )	_____
_____	Serum mucoprotein ( )	_____
_____	Total protein ( ), A/G ratio ( )	_____
_____	Cholesterol & esters ( ), ( )	_____
_____	Prothrombin & response to Vitamin K ( )	_____
_____	Stools - color ( )	_____
_____	Urine - bile ( )	_____

Balance Sheet Favors _____ Jaundice Due to: _____

Final Diagnosis _____ Date _____ Signature _____

* Check only positive findings.
● Insert values where applicable.

Fig. 9.—By centering all information on one sheet in order to balance factors favoring surgical against those favoring medical jaundice, diagnostic accuracy has improved.

admission diagnosis is re-evaluated and a second impression given. If surgery is performed, preoperative diagnosis may be compared with the final diagnosis. Emphasis should be placed on the fact that each aspect of the history, physical examination, and laboratory data is considered in the light of the duration and

severity of the jaundice. Specific figures and statements are not always necessary since the chart can be checked in either the medical or surgical column. A finding such as a 2 plus cephalin in long-standing, severe jaundice might well support either type and both columns are checked. After all data have been assembled, it has invariably been found that evidence strongly favors either surgical or medical management.

Such a chart will not be required in all patients, especially when the diagnosis is obvious from history and physical examination alone; but we have found it of great value in the smaller group of patients with long-standing jaundice. Since surgery has little to offer when performed under a mistaken diagnosis, it is well to spend the time balancing the weight of evidence which justifies surgery.

X-RAY STUDIES AND LIVER BIOPSY

Both x-ray studies and liver biopsy are of limited value in the jaundiced patient. The primary value of roentgenography is in an evaluation of other lesions of the gastrointestinal tract with particular reference to ruling out malignancy, the metastases from which may explain an obstructive jaundice. In considering the possibility of metastatic malignancy, the history of previous neoplasms must be ascertained. An enlarged duodenal loop may suggest the possibility of a pancreatic tumor; however, x-ray studies were of no help in the diagnosis of 60 per cent of our patients with carcinoma of the pancreas. As a matter of fact, of all x-ray studies performed in these patients, only 31 per cent were of any diagnostic value. There is a tendency to accept the finding of gallstones, which are seen in plain films of the abdomen, as diagnostic for extrahepatic obstructive jaundice. Gallstones alone should not preclude complete evaluation of the patient, since we have made several errors which were primarily due to overemphasis of this finding. Unfortunately, studies of the biliary tract even with radiopaque dyes given intravenously[14] are of very little value in the severely jaundiced patient.

The value of needle biopsy of the liver in differentiating intrahepatic and extrahepatic jaundice has been proved through a wide clinical experience. Certainly it is a less formidable procedure than surgical exploration. Needle biopsy will be of most value when laboratory data are confusing in the patient jaundiced for a long period of time. When nodules are present in the liver, biopsy may confirm the diagnosis of inoperable carcinoma. Evidence of extrahepatic obstruction, especially with an enlarged gall bladder, and a prothrombin of less than 50 per cent are the strongest contraindications to needle biopsy. These and other contraindications suggested by Schiff[13] have led us to use this procedure in only three per cent of our cases. The possibility of either bleeding or bile leakage requires that this procedure be done preferably in the morning with observation throughout the day with preparation for exploratory laparotomy if necessary.

ERRORS IN DIAGNOSIS

Inasmuch as many patients who become jaundiced are elderly, in poor nutritional status, and are generally poor surgical risks, the primary respon-

sibility of the surgeon is to establish, if possible, a correct diagnosis without laparotomy. Although we have not had a death following laparotomy in our own patients who had medical jaundice, it seems important to re-evaluate errors periodically in order to improve diagnosis. Such an evaluation was made in 1954,[4] since which time only two patients have had surgery for medical jaundice. All of our cases have been studied since 1946, so that any general improvements in diagnosis must be compared with earlier reports of others.[9]

Since it is nearly impossible to ascertain the accuracy of diagnosis in those patients in whom laparotomy or liver biopsy is not performed, we have evaluated our error percentage on the basis of the 207 patients operated upon. Table I

TABLE I. ERRORS IN DIAGNOSIS OF JAUNDICE (207 OPERATED CASES)*

NO. CASES	FINAL DIAGNOSIS	PREOPERATIVE DIAGNOSIS					PER CENT ERRORS
		CANCER	COMMON BILE DUCT STONES	STRICTURE	CHOLECYSTITIS	OTHER	
69	Common bile duct stone	4	64	0	0	1	7
15	Stricture	1	1	13	0	0	13
29	Cholecystitis	2	9	0	18	0	39
45	Cancer of pancreas	40	2	0	0	3	11
35	Cancer of biliary tract	25	6	4	0	0	29
6	Hepatitis	1	3	0	0	2	100†
7	Cholangitis and biliary cirrhosis	3	4	0	0	0	100‡

*While errors occur in the preoperative determination of the cause of obstructive jaundice, only the last two groups are of importance since surgery was of no value in these patients with medical jaundice.

†Stated to be operated to establish diagnosis.

‡Surgery of no value.

shows the preoperative diagnosis compared with the final diagnosis. The greatest accuracy has been in predicting a common duct stone. This is most likely due to the more typical history of colic and previous biliary tract symptoms. A total of 33 errors (16 per cent) were made in differentiating the cause of extrahepatic (obstructive) jaundice. Many factors in the history and physical examination tend to suggest an erroneous diagnosis in obstructive jaundice; however, the most important errors are those which lead to surgery for intrahepatic (medical) jaundice.

Thirteen of the 207 patients in whom operation was performed with a preoperative diagnosis of surgical jaundice were found to have only intrahepatic disease, an error of 6.4 per cent. Six were found to have hepatitis, and seven had either biliary cirrhosis or cholangitis. Of the 6 patients with hepatitis found at surgery, 3 had cholelithiasis by roentgenogram and these same 3 had an alkaline phosphatase of over 20 Bodansky units. No stones were found on common duct exploration. Liver biopsy showed hepatitis, and the gall bladder showed only mild chronic cholecystitis. It is difficult to suggest a method of avoiding such errors. The other 3 patients, however, all had laboratory data pointing to marked parenchymal damage, and history alone could not be relied upon to justify surgery. Five of these 6 patients did not have repeat laboratory tests and were observed only a few days before surgery.

The other seven patients with medical jaundice in whom error was made had either cholangitis or biliary cirrhosis. Watson[15] believes that some cases of hepatitis pass through a cholangiolitic stage; however, this does not seem to be the case in our 7 patients. One patient was on Thorazine and had histologic evidence of small biliary duct intraheptic obstruction. Three developed postoperative pancreatitis, and a reappraisal of their histories suggested that recurrent pancreatitis may have caused incomplete obstruction followed by the cholangitis. Furthermore, the 2 patients with biliary cirrhosis compare almost identically with 5 other patients with common duct stone and biliary cirrhosis. These findings all point to obstructive factors associated with infection as the cause of both cholangitis and biliary cirrhosis. From the standpoint of history, physical examination, and laboratory data we believe that these are the most difficult cases to diagnose correctly. Perhaps they represent the "small percentage of cases" which Lipp and associates[9] state may continue to require surgery. The improvement in our own diagnostic accuracy over the past two years through more careful attention to all factors in these difficult cases suggest that the number of errors can be definitely lowered.

PROGNOSTIC FACTORS

The high morbidity and mortality in jaundiced patients requires continued re-evaluation to assure progressive improvement. The use of vitamin K has certainly improved mortality from bleeding; but we have found that shock due to chronic or acute blood deficits still leads either directly or indirectly to over half of the deaths in these patients. Recent studies have shown an average preoperative blood volume deficit of approximately three pints in the deeply jaundiced patient.[5] This deficit is most likely due primarily to the loss of weight which occurs with prolonged jaundice, but bone marrow depression and hemolysis are also present to some degree.

A review of our own cases shows that hypotension was associated with the development of uremia which led to a prolonged hospitalization and complications resulting in the death of over one-half of these patients. Six out of 7 patients with benign obstructive jaundice and 10 out of 22 with malignant obstructive jaundice developed hypotension either during or shortly after surgery. Three out of 4 (73.3 per cent) of these patients did not receive blood before surgery. Blood loss was not considered great in most cases, and an average of less than two pints was transfused during the surgical procedure. All of these patients developed progressive uremia following the hypotension, and many were problems in fluid and electrolyte balance. It was interesting to note that despite hypotension, with a blood pressure below 90 systolic, 13 out of the 16 patients did not have a pulse elevation over 100. This relative bradycardia may explain why a significant drop of blood pressure alone was often not viewed with significant alarm.

Whether or not the frequent occurrence of uremia in these patients composed the so-called "hepato-renal syndrome," the fact remains that hypotension in the severely jaundiced patient may be a serious complication. A drop in

blood pressure during or after surgery should be prevented by adequate replacement of blood volume before surgery and careful replacement of blood losses. It should be remembered that the severely jaundiced patient will have lost an average of twenty-five pounds in weight and two to three pints of blood will be required before surgery. Blood volume determinations may be required as a more accurate guide to replacement therapy in the very poor risk patient. A urinary retention catheter should be used in most cases to more closely follow urinary output. A rising blood urea nitrogen is a poor prognostic sign. Uremia so prolongs the postoperative course that these patients develop additional serious complications. Postoperative gastrointestinal hemorrhage has been the second most common cause of death. Six patients died from bleeding from esophageal varices, peptic ulcer or from bleeding into the peritoneal cavity. Vitamin K therapy must be given both before and after surgery.

Preoperative laboratory data regarding liver function are of little prognostic significance. Cholesterol esters of less than 20 per cent were found in one-third of our patients who expired. They have been considered a poor prognostic sign. However, there was little other evidence for severe liver damage. Although a few patients have developed liver abscesses and severe cholangitis before death, liver failure has not been a direct cause of death.

SUMMARY

Improvement continues in the preoperative diagnosis of the jaundiced patient as indicated by an evaluation of 207 such patients subjected to laparotomy over the past nine years. The use of a "Jaundice Balance Sheet" has been of great value in deciding for or against surgical intervention. Each factor of the history, physical examination, and laboratory evaluation is weighed either for medical or surgical jaundice.

Experience indicates that the duration and severity of the jaundice must be considered in evaluating the significance of each finding. Particularly, laboratory data in patients with long-standing jaundice may be confusing. Only a few such tests are needed in most jaundiced patients. These include determination of the alkaline phosphatase, cephalin flocculation (or thymol turbidity), prothrombin response to vitamin K and the serum mucoprotein. Determinations of the total protein, albumin-globulin ratio, bromsulphalein retention, and cholesterol esters are of more value in prognosis than diagnosis.

Of the 207 jaundiced patients subjected to laparotomy since 1946, 13 were found to have intrahepatic jaundice. Only 2 of these errors in diagnosis have been made since the institution of the policy two years ago, of balancing all factors in each patient for or against surgical intervention. Determination of the serum mucoprotein has been the most recently developed laboratory test in evaluating the jaundiced patient; however, repeated critical appraisals of our diagnostic accuracy have been the most important factor in improving results.

The mortality in patients with long-standing extrahepatic obstructive jaundice is still too high. Over half of our 29 patients who died following

surgery for extrahepatic obstructive jaundice developed progressive uremia after a period of hypotension. Two or three pints of blood before surgery and a careful replacement of acute blood losses are necessary to prevent this hypotension in the patient who has been jaundiced for more than a few weeks. Postoperative bleeding, usually into the gastrointestinal tract, continues to be a frequent complication and vitamin K must be given both before and after surgery.

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Surgical History

CONDUCTED BY JOHN R. PAINE, M.D.

THE HISTORICAL DEVELOPMENT OF THE SURGICAL TREATMENT OF INGUINAL HERNIA

ROBERT I. CARLSON, M.D., NASHVILLE, TENN.

(From the Surgical Service, Thayer Veterans Administration Hospital, and the Department of Surgery, Vanderbilt University School of Medicine)

THE evolution of the surgical treatment of inguinal hernia encompasses the trials and errors of surgeons practicing their art during the past twenty to twenty-two centuries. The earliest mention of an inguinal hernia is found in the Ebers Papyrus (1550 B.C.), in which it is apparent the pre-Homeric Egyptian physicians treated inguinal hernia by conservative means. Mettler[39] states that she knows of no mention of the surgical treatment of hernia in the works of Hippocrates. The first description of an operation for inguinal hernia is attributed to Celsus, a Roman (25 B.C. to A.D. 50). Celsus was not a physician, but an encyclopedist; and modern experts feel that the operations contained in his compendium of six volumes (two of which were devoted to surgery) were taken from numerous surgeons who antedated him. Many feel that Heliodorus, a contemporary of Celsus, was probably the kelotomist cited by him. In turn, Heliodorus is thought to have derived his surgical knowledge from the Alexandrian surgeons, a group which flourished during the reign of Ptolemies in Egypt between the fourth and first centuries B.C.

In his description of the procedure, Celsus advised that the operation be done through either a groin or a scrotal incision; the hernia sac was separated from the structures of the cord and the sac was transected after the contents had been reduced. Bleeding vessels were tied with ligatures, which were allowed to protrude from the wound, and two lint strips dipped in vinegar were placed in the incision to incite the formation of a cicatrix. Celsus advocated saving the testicle, in contrast to later Roman authors who performed castration.

Following this promising start nearly twenty centuries ago, no significant progress was made until the latter part of the nineteenth century, when the epic-making contributions of Joseph Lister made aseptic surgery possible. Prior to the introduction of aseptic surgery all attempts at hernia repair were carried out through a dilated external ring for fear of incision of fascial planes, as this invited infection and usually led to dire consequences. Each

of these attempts was what Burton[12] calls a kelotomy or a herniotomy. I prefer the former term so as to avoid confusion with the present-day operation of herniotomy.

In his paper Andrews[2] stated:

> In the two millenia which intervened from our first knowledge of hernia surgery up to the age of asepsis, the surgical art was at a standstill. Everybody knew that any form of suturing was not only futile but positively dangerous; sutures used were ordinary thread, naturally unabsorbable. The ends of either sutures or ligatures were left hanging from the wound until they sloughed out. Obviously, union of surfaces thus sutured must have been the exception rather than the rule. No surgeon dared to incise a fascial plane with the deliberate intention of suturing it. For this reason the inguinal canal was never opened, and therefore adequate surgery was never accomplished.

THE KELOTOMY ERA

During the Middle Ages, when Greek and Roman surgery was largely forgotten, with the exception of Galen, who had little or nothing to say about surgery, for he was an internist, those procedures that were done were usually accompanied by castration. During this period surgeons assiduously avoided operating upon patients with a strangulated hernia, for a poor result not only tended to ruin the reputation of the surgeon involved but in many areas was a threat to his life.

Taxis, in order to reduce an incarcerated hernia, was known to have been practiced by Praxagoras of Cos who lived about 335 B.C. Attempts at reduction were practiced throughout the Middle Ages, but a purposeful operation in the treatment of a strangulated hernia was not described until the time of Pierre Franco, a Frenchman, who was born about the year 1500. Heister (1683-1758) described a case in which gangrenous bowel was resected, with implantation of the ends of normal bowel into the margins of the wound with a successful result.

With the gradual acceptance of the principle of human cadaver dissection, which originated at the University of Bologna in Italy as early as A.D. 1200 and was permitted throughout Europe by the sixteenth century, man's knowledge of anatomy grew rapidly. Yet, it was not until the eighteenth century that a greater knowledge of the anatomy of the inguinal region and of the several varities of hernia was attained. In 1710 Alexis Littré reported two cases in which a Meckel's diverticulum was found in the hernia sac. In 1731 deGarengeot was the first to describe a hernia which contained the appendix. In 1768 de Gimbernat described the ligament which now bears his name; he later advocated the division of this ligament in cases of incarcerated femoral hernia. In 1785 Richter described a hernia in which only a part of the circumference of the intestine had herniated. In 1804 Sir Astley Cooper made a study of femoral hernia and described Cooper's ligament. In 1819 Scarpa published a monograph on hernia, including a description of a sliding hernia.

Despite periodic outbursts of enthusiasm for the surgical treatment of hernia, the poor results attained led to intervals when surgeons lost all in-

terest in a surgical attack and trusses were extensively used. The use of trusses dates back to 900 B.C., the estimated date of origin of a Phoenician statuette of a human figure with bandages in both inguinal regions.

During the nineteenth century the injection treatment of hernia was championed by Velpeau in France and Pancoast in this country. In 1837 Velpeau advocated the injection of iodine into the hernia sac, and Pancoast used tincture of cantharides in 1847. All of these steps represented but little progress until the time of Joseph Lister, who, in 1867, gave his first paper on the use of a carbolic acid spray in an attempt to carry out an operation under antiseptic conditions. Later, during the period in which a feud raged between the pro-Listerians and anti-Listerians, the concept of aseptic surgery gradually emerged. This was the turning point in the surgical treatment of inguinal hernia.

Before considering the operations of Bassini, Halsted, and the other founders of modern-day hernia surgery, we might summarize the thoughts of American surgeons practicing during the eighth decade of the nineteenth century, as exemplified by Agnew's textbook of surgery published in Philadelphia in 1878. D. Hayes Agnew was professor of surgery at the University of Pennsylvania. He discussed the various operations in vogue in the treatment of inguinal hernia and summarized as follows:

> After a careful review of the various operations proposed and practiced for the radical cure of hernia, not one can be said to be satisfactory; and it is a question admitting of grave doubt whether, in the present state of our knowledge on the subject, the surgeon is justified in resorting to any other treatment than that of a properly adjusted truss.[1]

Agnew stated, however, that if an incarcerated hernia could not be reduced by taxis, operative therapy should be carried out.

Decrying the old system of preparing for taxis, namely, venesection and tobacco clysters, he felt that the patient should be anesthetized with chloroform or ether, with the understanding that if reduction was not accomplished an operation would be carried out immediately. In preparation for the administration of the anesthetic, he counsels that the patient be placed in a warm bath, and then gives the following advice:

> . . . a large enema of flax seed, tea and turpentine or of salt water thrown into the bowel immediately after he comes out of the water. The warm bath tends to relax the parts about the region of the hernia, and the stimulating enema favors intestinal peristalsis by which the obstruction causing the stricture may be moved from the protruded bowel. Very gentle use of taxis should be made, and after the reduction a truss should be applied to hold the hernia in place. If, however, these measures fail and the tenderness of the parts increase, ice may be applied to the tumor and a cathartic administered.

HERNIOTOMY AND HERNIORRHAPHY

Although Lister's first paper was published in 1867, opposition to his work was sufficient to prevent the widespread use of his antiseptic method in Europe and in America for some fifteen to twenty years. In his textbook Professor

Agnew stated at the time of publication in 1878 that he had been using Lister's carbolic acid spray technique in his operating room for only one year. However, there was a gradual acceptance of the method; and with the possibility of doing an aseptic operation with the patient under anesthesia, the energy of numerous surgeons was redirected toward the surgical cure of inguinal hernia.

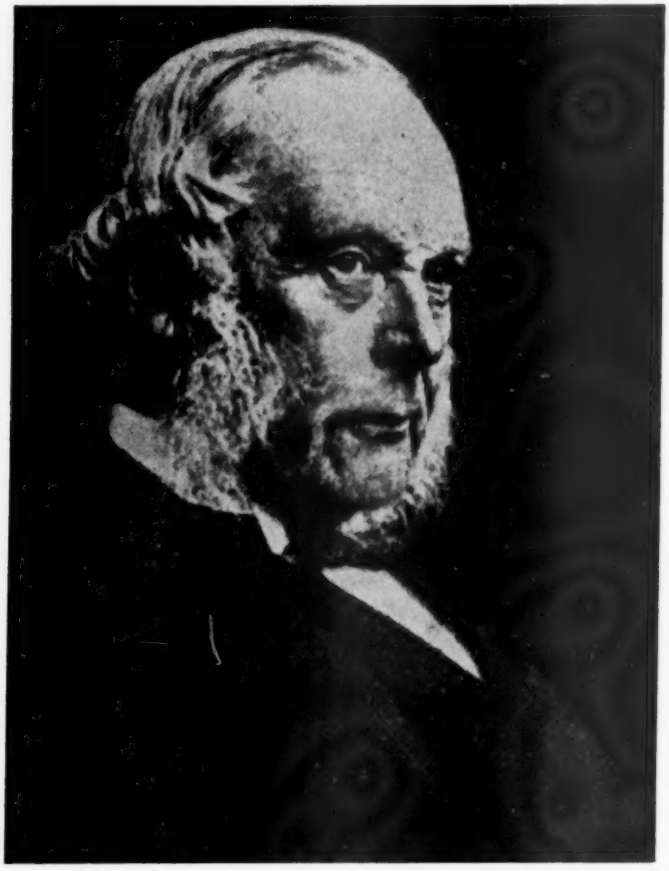

Fig. 1.—Joseph Lister (1827-1912).

Probably the first step in this direction was accomplished by Lucas-Championnière, who, in 1881, opened the inguinal canal for the first time. Here we see the transition point from a kelotomy to a modern herniotomy, a tremendous advance in the surgical therapy of hernia.

Macewen's contribution, although a kelotomy, must be mentioned, for this Scotch surgeon seemingly was the first to recognize the importance of the transversalis fascia in the repair of an inguinal hernia. His operation, described in 1869, consisted of an attempt at creating a baffle of the preserved hernia sac, this tampon being placed on the inner aspect of the internal ring, with an attempt at closure of all the layers of the inguinal canal with mattress sutures, frequently with compression of the cord.

Although there is controversy among medical historians as to the surgeon who first transplanted the cord, and therefore did a herniorrhaphy, I feel that the honor should go to Edoardo Bassini. Although Watson in his textbook *Hernia,* published in 1948, accords the honor to Marcy of Boston, I have found in reviewing the article cited by Watson and also a previous reference by Marcy that no mention is made of herniorrhaphy. The original papers describe two patients with strangulated hernias upon whom Marcy operated, with reduction of the contents of the unopened sac into the abdomen and closure of the neck of the hernial orifice with catgut sutures. No mention is made as to the manner

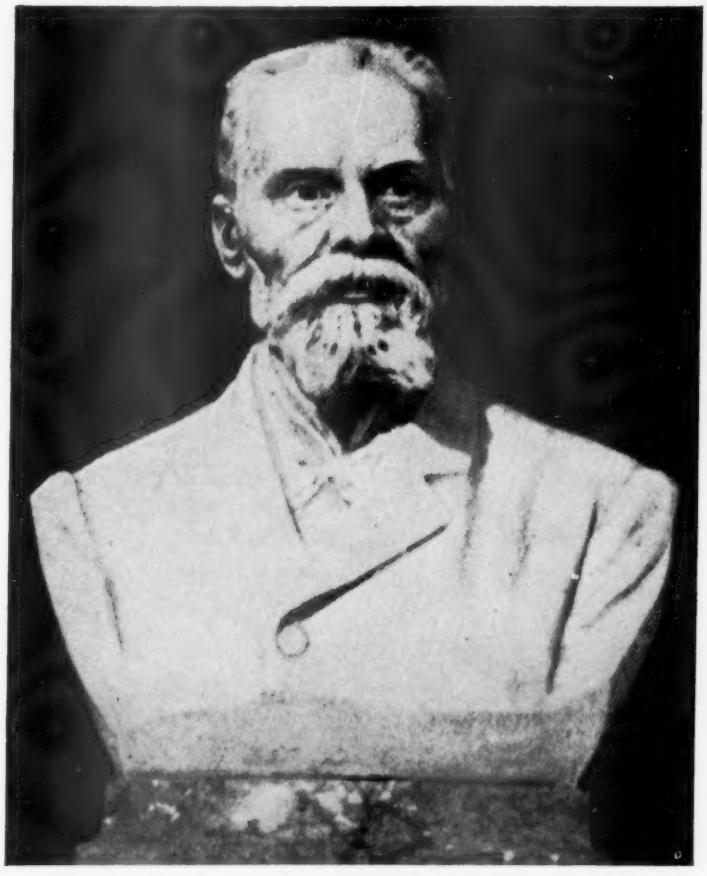

Fig. 2.—Edoardo Bassini (1847-1924). Bust in the Padua Clinic.

of treatment of the layers of the abdominal wall. Burton states that a review of Marcy's textbook published in 1892 leaves doubt as to the exact date when he first performed a herniorrhaphy similar to that of Bassini.

Dr. Halsted has had many adherents who have claimed that he was the originator of herniorrhaphy. Although Halsted and Bassini were contemporaries, priority of both publication and of practice seemingly is on the side of Bassini. This professor of surgery at Padua did his first herniorrhaphy in 1884 and first reported his operation in an Italian journal in 1887, and later in

the *Archiv fur Klinische Chirurgie* in 1890, a paper which was read before the German Surgical Society in 1889. I have not had the opportunity to review his Italian paper, but I have reviewed the paper written in German in 1890. Bassini's operative technique is as follows:

> The skin incision is made and the external oblique is opened, with exposure and isolation of both the subcutaneous and abdominal inguinal rings. The spermatic cord is isolated, as well as the neck of the sac and the internal ring; this is done with a forefinger or with a blunt instrument and it is not difficult, be the hernia congenital or acquired. The isolation of the sac must extend up into the iliac fossa. Then the sac is opened and the contents reduced, if present, and the thickness of the sac neck is determined. If the hernia is incarcerated, I open the neck of the sac as widely as necessary. After the reduction of the contents, I place a snare over the neck of the sac and then cut it off 1 cm. from its point of occlusion with the snare. A purse-string suture is used in addition to the snare if the sac is large.
>
> I then draw the cord and the testicle anterior to the external oblique and sew the lower leaf of the reflected portion of Poupart's ligament to what is termed the "dreihaupt", which consists of the aponeuroses of the internal oblique, the transversus abdominis, and the "vertical fascia of Cooper" (transversalis fascia). These interrupted sutures, placed behind the cord, extend from the pubis to the anterosuperior iliac spine. Each suture catches two to three centimeters of the edge of the medial flap, and the two lowermost sutures catch the rectus abdominis muscle at the pubic tubercle. The cord and then the testicle are laid on this layer and the external oblique is sewn to Poupart's ligament down to the edges of the subcutaneous ring. The skin is closed and a dressing applied. Drainage is used only when a large hernia is repaired.[7]

Bassini's statistics, comprising 262 operations done since 1884, are summarized in Table I.

TABLE I. BASSINI'S RESULTS (216 PATIENTS WITH 262 HERNIAS)

Nonincarcerated	251 cases	
Age range	13 months to 69 years	
Type	232 indirect	
	19 direct	
Etiology	196 congenital	
	55 acquired	
	17 ectopic testicle	
Follow-up period		
1 Year to 4½ years; No recurrence		108
6 Months to 1 year; No recurrence		33
1 Month to 6 months; No recurrence		98
Recurrence		7
Lost to follow-up		4
Death		1
		251
Incarcerated	11 Cases	
Nine recoveries		
Two deaths		

The impact of Bassini's results on the surgical world was considerable, for the mortality and recurrence rates were so much lower than those attained by contemporary operations. Bull stated that following a Czerny operation (or the Banks procedure as it was called in England) the recurrence rate was 40 per cent within one year. This procedure entailed the ligation and excision

of the sac, with suturing of the pillars of the external ring. Billroth, from whose clinic a report was given at the same meeting at which Bassini's paper was read in 1889, had a death rate of 7 per cent and the rate of recurrence was quite high.

In 1889 Dr. Halsted read a case report to the Johns Hopkins Medical Society, in which he proposed a new type of hernia repair which entailed transplantation of the cord following excision of the hernia sac. A rather meager description of the technique was given, and the paper was published in the Johns Hopkins Hospital Bulletin (1889)[16] as a report by the secretary of the society, a Dr. Robb.

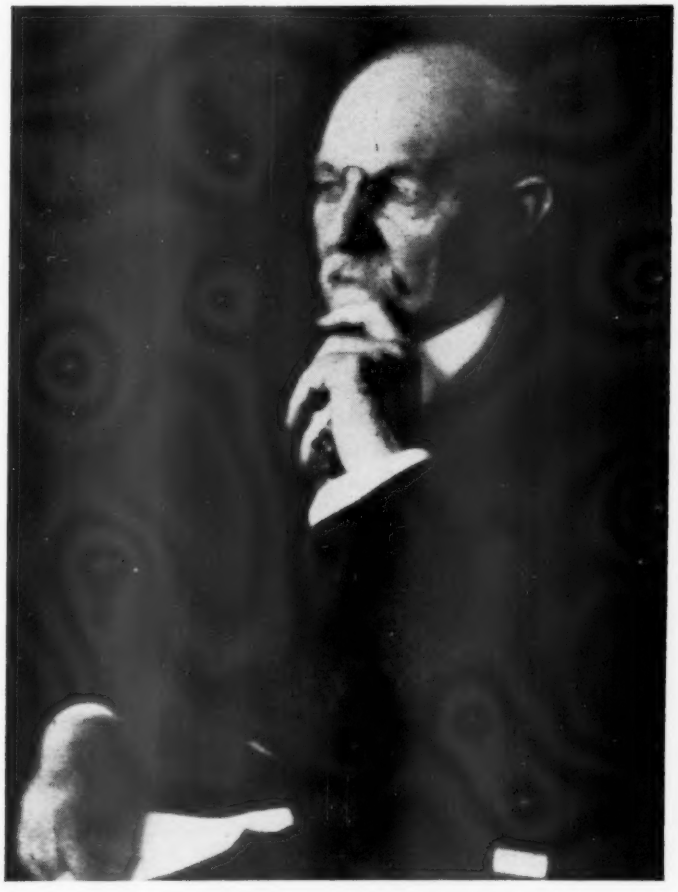

Fig. 3.—William S. Halsted (1852-1922).

In 1893, however, in the Johns Hopkins Hospital Bulletin, Dr. Halsted[17] gave a complete description of the Halsted I procedure, as follows:

> The skin incision extends from a point about 5 cm. above and external to the internal abdominal ring to the spine of the pubes. The aponeuroses of the external oblique, the internal oblique, and the transversus muscles, as well as the transversalis fascia, are cut through from the external abdominal ring to a point 2 cm. above and external to the internal ring. The sac is carefully

isolated and opened and its contents replaced. With the division of the abdominal muscles and the transversalis fascia, the so-called neck of the sac vanishes; there is no longer constriction of the sac. Communication between the sac and the abdominal cavity is sometimes large enough to admit one's hand. The sac having been completely isolated and its contents replaced, the peritoneal cavity is closed by a few silk sutures, either in the form of a mattress suture or by a continuous suture. The spermatic cord is then devascularized, leaving but one artery and two veins so as to reduce its bulk. After the cord is raised out of the wound by means of a hook, six or eight deep mattress sutures, which pass through the aponeurosis of the external oblique and through the internal and transversus muscles, as well as the transversalis fascia on one side, then pass beneath the cord and through the transversalis fascia and Poupart's ligament, as well as fibers of the aponeurosis of the external oblique muscle on the other side, are placed. The two uppermost sutures are placed on either side of the internal abdominal ring; if they are placed too far apart the hernia might recur. The space should be wide enough only so that each suture will gently grip the cord. The precise point out to which the cord is transplanted depends upon the condition of the muscles of the internal abdominal ring; if these are thick and firm and present broad raw surfaces, the cord may be brought out here; but if the muscles are attenuated and present thin edges, the cord is transplanted further out, namely to the subcutaneous layer. The skin edges are brought together by buried sutures of very fine silk. The transplanted cord lies on the aponeurosis of the external oblique muscle and is covered by skin only.

In this paper, Halsted commented that his operation was very similar to that of Bassini, despite the obvious fact that the position of the cord was quite different. He noted that Bassini did not excise the superfluous veins of the cord; and he felt that Bassini's two rows of sutures were a disadvantage, because, "Unless it should be demonstrated by comparison of the results of the two methods that there is something to be gained by these additional stitches, it would be well for the sake of the wound and the operator to discard them."[17]

Halsted kept the patient in bed for twenty-one days, feeling that at the end of this time the wound would be most strong. He never drained the wound, although he used drains for seven days in his 1889 report. He stressed the importance of lack of tension on suture lines in order to provide for good circulation. Halsted's results at this time showed that 82 operations had been done over a period of three and one-half years, dating back to 1888 or 1889. He had used his new technique in 58 cases and had found that not one hernia had recurred in those which healed per primum. Since the development of infection meant that the wound was opened widely and allowed to heal by granulation, he felt that these cases could be discarded, for they were not sewn up in the manner which he prescribed. There were 6 recurrences in these 58 cases, to none of which Dr. Halsted felt that he should lay claim.

The next step in the evolution of modern-day herniorrhaphy was the imbrication of the external oblique in order to further buttress the abdominal wall in the treatment of inguinal hernia. Koontz[22] states that Lucas-Championnière was the first to imbricate the aponeurosis in 1892, but Andrews popularized the method, particularly in America, in 1895.

The Ferguson operation was the next notable advance and was presented to the American Medical Association at its Fiftieth Anniversary Meeting in 1899. Although A. H. Ferguson had advocated the Macewen procedure with transplantation of the cord into the subcutaneous tissues in 1895, by 1899 he had abandoned transplantation because of too many recurrences and because of difficulty with atrophy of the testicle. He stated:

> I have never been satisfied with the raising and transplantation of the cord. In more cases than have been recorded the testicle has come to grief by this unnecessary procedure. Tearing the cord out of its bed is without an anatomic reason to recommend it, a physiological act to suggest it, an etiological factor in hernia to indicate it, nor brilliant surgical results to justify its continuance. Leave the cord alone, for it is the sacred highway along which travel vital elements indispensable to the perpetuity of our race.[14]

Ferguson did not believe in devascularizing the cord, but felt that cremasteric fibers should be removed if they caused undue thickening. He stressed the importance of repair of the transversalis fascia in the region of the internal ring. The internal oblique and the transversus muscles were sutured to the inner aspect of Poupart's ligament to restore their normal origin; this was done anterior to the cord. The edges of the external oblique were then approximated, restoring the normal external ring. He pointed out that he had done 64 operations during the previous eighteen months; 61 of the 64 healed by primary union, despite the fact that rubber gloves were used in only 6 operations.

The next advance was a paper by Halsted[18] published in the *Johns Hopkins Hospital Bulletin* in 1903. In this paper he pointed out that as a result of an experience with the repair of about 1,000 hernias during the preceding fourteen years his original operation had been modified and that the new procedure did not encompass transplantation of the cord. His reason for abandonment of the Halsted I operation was the high incidence of atrophy of the testicle. In 1903 Dr. Halsted felt that devascularization of the cord was still important, being done in all cases except in children. In his description, a high ligation of the sac with use of the Kocher maneuver to fix the stump of the sac to the anterior abdominal wall was advocated; the cremaster muscle was then used as the first layer, suturing it to the undersurface of the internal oblique anterior to the cord. Following this, the internal oblique was sewn down to Poupart's ligament and finally the external oblique was imbricated upon itself. Catgut was used to suture the internal oblique to Poupart's ligament.

Halsted also made mention of creating a fascial flap from the anterior rectus sheath when necessary to further reinforce the repair, stating that he and Bloodgood developed this procedure about 1896. He noted that if excessive tension obtained when the internal oblique was sewn to Poupart's ligament that a relaxing incision in the anterior sheath of the rectus might well add to the effectiveness of the procedure. He summarized the results previously reported by Bloodgood in 1899, at which time they had had 13 recurrences in 301 cases which healed per primum, an incidence of recurrence of 4.3 per cent.

Koontz[22] states that Halsted made no claim to the originality of this Halsted II procedure and he (Koontz) feels that the operation should be called the Ferguson-Andrews procedure.

HERNIOPLASTY

In the 1880's and 1890's, when surgeons became discouraged with the results of herniotomy in the repair of inguinal hernia, an appreciation of the structural defects in a direct inguinal hernia gave rise to the first varieties of herniorrhaphy to overcome these weaknesses. The operations of Bassini and Halsted markedly improved the poor results attained by use of herniotomy alone. A similar disappointment in the surgical results following herniorrhaphy later led to a revolt against the routine use of the inguinal ligament in hernia repair.

The first use of Cooper's ligament rather than Poupart's ligament in a hernia repair is attributed to Lotheissen,[25] a German, who in his article in 1898 gave credit to Narath for having used this technique previously. Lotheissen found in attempting to repair a recurrent hernia that the inguinal ligament was so attenuated as to be useless. Applying his knowledge of the anatomy of the inguinal region, he exposed Cooper's ligament and sewed the layers of the abdominal wall down to this ligament, thereby closing the femoral ring, while doing a plastic reconstruction of the floor of the inguinal canal. He did this procedure on 12 different occasions. However, his contribution went unheralded; and the current popularity of use of the iliopectinal ligament in hernia repair dates primarily from the work of McVay and Anson. Although Astley Cooper described the ligament which bears his name in 1804 and suggested that it might be used in the repair of a femoral hernia, he did not use it in any operation to our present knowledge. Annandale was the first one to use the ligament of Cooper in the repair of a femoral hernia (1876).

In a series of papers published from 1938 to 1942, Anson and McVay[5, 35, 36] reported their observations on the anatomy and physiology of the groin region on the basis of over 300 dissections. They stated that they found no anatomic justification for suturing transversalis fascia or any of the other inguinal strata to the inguinal ligament:

> The latter serves neither as origin nor insertion for the transversus oblique layers, the relationship being simply one of continuity. The advantage of Cooper's ligament is that it is a thick, tough, ligamentous structure extending from the pubic tubercle along the iliopectineal eminence to the vicinity of the femoral vein.

They pointed out that the transversalis fascia and the aponeurosis of the transversus abdominis normally insert into Cooper's ligament, and in a repair this relationship should be re-established.

In 1948 and 1949 McVay[37, 38] published the details of his operative procedure. Using a transverse incision along Langer's lines the inguinal canal is opened. The cord is carefully isolated from the canal by incising the cremasteric fascia. In the event an indirect sac is present, it is isolated up to the abdominal ring, is opened, and Hesselbach's triangle and the femoral ring are palpated to

exclude accessory sacs. In the case of a direct or femoral hernia, the cord is carefully searched for a congenital indirect sac. After the sac has been ligated at least 2 cm. above the ring, the size of the internal ring is carefully determined and the condition of the walls and floor of the inguinal canal is evaluated. In the presence of adequate musculofascial supports and with an abdominal ring that is no larger than 2 cm. in diameter, all that is necessary is to tighten the ring by approximating the transversalis fascia to the subjacent anterior layer of the femoral sheath by one or two median silk sutures. These sutures are placed medial to the cord. If the ring is larger than 2 cm. in diameter or if there is any laxity of the fascial structures of the canal, McVay feels that a Cooper's ligament repair should be carried out and that there is no place for a repair in which the inguinal ligament is used.

With the decision that a hernioplasty should be done rather than a herniotomy, a relaxing incision is made in the anterior sheath of the rectus muscle and the attenuated structures in the floor of the canal are excised. Following this, the transversalis fascia and the conjoined tendon are then sewn to the ligament of Cooper starting at the pubic tubercle and with sutures that are only 2 mm. apart this suture line is carried up to the medial wall of the femoral vein, obliterating the femoral canal. At this point additional sutures uniting transversalis fascia and transversus muscle are brought down to the fascia overlying the anterior wall of the femoral vessels and to the fascia overlying the pectineus muscle. This is accomplished by displacing the cord laterally, and ultimately the internal ring is located 1 to 1.5 cm. lateral to its original position. Following this, the cord is allowed to drop back into its bed and the external oblique is closed over it.

In 1949 McVay[38] reported the results of operations on 100 patients, 56 of whom had a Cooper's ligament repair. With a follow-up period of up to eight years, Dr. McVay found no evidence of recurrence in these 56 patients, although 4 were lost in the follow-up period.

Zimmerman,[46] in an editorial published in 1948, raised certain questions as to the routine use of Cooper's ligament in all hernia repairs. He pointed out that most recurrences of hernia following an inguinal ligament herniorrhaphy did not occur below the inguinal ligament, as was postulated by McVay. He noted that a Cooper's ligament repair was a more difficult operative procedure and posed at least a potential danger to the great vessels as the layers were sewn down to the ligament. He also pointed out that the weak area in the repair was where the suture line was carried down to the vicinity of the femoral vessels. It was at this transitional angle that Zimmerman felt that most recurrences would occur unless the inguinal ligament was used as the lateral anchor in this phase of the procedure.

Burton[11] discussed this matter as recently as 1954, and he too felt that the transitional angle was the danger point in the McVay repair. He pointed out that in order to prevent difficulty in this area the external oblique should be sewn to the femoral fascia and that the edge of the inguinal ligament should

be approximated to Cooper's ligament in order to prevent an interligamentous recurrence. This requires transplantation of the cord to the subcutaneous layer.

Harkins,[19] in 1949, discussed the question and was firmly on the side of McVay. In reviewing the literature of the past decade, he noted that the operation of Bassini had largely been abandoned, particularly in Great Britain, since the onset of World War II. He quoted Ogilvie,[40] who in 1947 stated, "Bassini's operation spans nothing, but makes the weak area still weaker."

Harkins sought to answer Zimmerman's complaints about the McVay repair, pointing out that any attempt to approximate the inguinal ligament to Cooper's ligament would prevent the functional closing of the abdominal ring with the normal contraction of the reconstituted transversus abdominis and transversalis layers being inserted into Cooper's ligament. Harkins reported the results of 398 McVay procedures done during the past nine years and he noted but 3 recurrences, an incidence of 0.8 per cent. However, he did admit no concerted effort had been made to evaluate these cases just prior to the report.

Other varieties of hernioplasty entail the use of fascial sutures, muscle, fascial or cutis grafts, or foreign materials in the plastic reconstruction of the inguinal canal.

McArthur made one of the early contributions in the development of hernioplasty when he suggested in 1901 that the repair of the inguinal canal be carried out with a fascial suture taken from the edge of the external oblique muscle, this strip being used as a pedicle graft. The use of fascial sutures in hernia repairs has continued to the present time; other names which should be mentioned are those of Gallie and LeMesurier, who advocated the use of a free fascial suture in 1923. In Dr. Halsted's paper of 1903 he makes mention of the use of a flap of the rectus fascia as being used by Dr. Bloodgood in 1897. Heterologous ox fascia has been advocated in hernioplasty by Koontz (1926), Glasser (1933), and Eagen (1935). Cutis grafts were advocated by Loewe in 1913, and in 1938 Mair advocated the use of whole-thickness skin implants. A vitallium plate was used by McNeely and Glassman in 1946; the use of tantalum mesh to reinforce the repair has been advocated by Koontz (1949) and others. All and all, it is the unusual hernia that requires the use of preserved or foreign materials, the greatest use for which occurs in huge ventral hernias and rarely are necessary in the repair of an inguinal hernia.

DISCUSSION

Recently I reviewed all of the recurrent inguinal hernias repaired at the Thayer Veterans Administration Hospital during a three-year period (from January, 1953, to December, 1955). During this time 51 recurrent inguinal hernias, in 42 patients, were repaired. The operative records of each patient were carefully reviewed in order to determine whether the recurrence was due to a dehiscence or weakness of the reconstructed floor of the inguinal canal, a "true" recurrence, or whether the recurrence was due to a technical error which would have caused a breakdown in the repair, regardless of the ligament

originally employed. Two different types of technical errors were demonstrable. The first of these was a small defect in the floor of the canal just above the pubic tubercle; this defect was felt to be due to a technical error, a broken or avulsed suture, if it was no greater than 2 cm. in diameter and if the remainder of the reconstructed floor was sound. This type of recurrence was found in 7 cases. The second variety of technical error was found at the internal ring; if the neck of the recurrent indirect sac was less than 2 cm. in diameter and the entire reconstructed floor of the inguinal canal was sound, it was deemed ascribable to a technical error in closing the internal ring, using the same criteria McVay[37] used in determining whether the patient required a herniotomy with a plastic repair of the internal ring or a McVay hernioplasty.

TABLE II. FIFTY-ONE RECURRENT HERNIAS IN FORTY-TWO PATIENTS (JAN. 8, 1953, TO DEC. 6, 1955)

Patients with hernia repaired at Thayer V. A. Hospital		14
Patients with hernia repaired elsewhere		28
		42
Bilateral hernias present at some time	26 (62 per cent)	
Bilateral hernias repaired at one time	16 (37.6 per cent)	
Multiple Recurrences		
1 patient	9 recurrences (3 in this study)	
1 patient	3 recurrences (2 on right; 1 on left)	
5 patients	2 recurrences	
	Unilateral—1	
	Bilateral—4	
35 patients	1 recurrence	
42 patients	51 recurrent hernias	

Of the 42 patients with a recurrent hernia in the study, 28 (66.7 per cent) had their original repair at another hospital, while 14 (33.3 per cent) had a recurrence of a hernia repaired at the Thayer Hospital. I believe this merely reconfirms the general impression that patients suffering with a recurrence usually seek out a second surgeon or institution for the repair of the postoperative complication.

Sixty-two per cent of the patients had a contralateral hernia present at some time, and 38 per cent of the group had bilateral hernias repaired in one stage.

Eighty-three and one-third per cent of the patients experienced only one recurrence; of the remaining sixteen and two-thirds per cent, one patient had 9 recurrences, only 3 of which appear in this study; another patient had 3 recurrences; and 5 patients had 2 recurrences. With the exception of the man who had a history of 9 recurrences following hernia repairs, and who had very poor tissues, it is felt that the patients had sufficiently adequate fascial structures, so that recurrence could not be due to a failure on the part of the patient but represented an error that could be ascribed to either the surgeon or the operation that he performed upon the patient.

Among the 51 recurrent hernias repaired, it was found that 23 (45 per cent) were recurrences which could be ascribed to a technical error, while 28 (55 per cent) were "true" recurrences with a breakdown of the floor of the inguinal canal. It is interesting to note that among the 14 patients who had

their original operation at the Thayer Veterans Administration Hospital one-half of the recurrences encountered were due to technical defects.

In considering the type of the original hernia repair and the variety of recurrence, it is noticeable that all types of hernia repair were found to give rise to "true" recurrences as well as those due to technical errors.

Of particular interest were the 14 patients who had had their original operation carried out at our hospital. In this group 8 patients had a McVay repair initially. It was found that 4 of these 8 patients had a technical recurrence, whereas 4 had a "true" recurrence. In reviewing the original operative notes of these 8 patients, it was of interest to note that not one of the 8 patients had had a relaxing incision made at the time of the original procedure. At least in those 4 patients who had a technical recurrence, it is probable that this could have been obviated if a relaxing incision had been made as Dr. McVay advises to overcome excessive tension on the suture lines.

TABLE III. TYPE OF RECURRENCE

	NUMBER	TRUE RECURRENCE	TECHNICAL DEFECT
Outside group	37	21	16
Thayer group	14	7	6
Total	51	28 (55 per cent)	23 (45 per cent)

ORIGINAL REPAIR AND TYPE OF RECURRENCE

	NUMBER	TRUE RECURRENCE	TECHNICAL ERROR
Bassini	24	14	10
McVay	10	4	6
Halsted I	9	3	6
Ferguson	3	3	0
Herniotomy	2	2	0
Unknown	3	2	1
Total	51	28	23

I personally feel that the inguinal ligament herniorrhaphy should not be cast out of our surgical armamentarium as advised by McVay. It is my opinion that the musculofascial defects in the floor and walls of the inguinal canal in most indirect, and in some direct, hernias can be satisfactorily corrected by a Halsted I herniorrhaphy done in layers without devascularizing the cord. The selection of the type of repair to be used should be made at the operating table on the basis of the operative findings rather than to follow a preconceived stereotyped ritual.

Obviously, if the obligatory indications of Burton[12] are present, a McVay procedure should be carried out. There will be instances when the relative indications for a McVay repair should hold sway. When a McVay repair is done, however, a relaxing incision must be used in order to prevent excessive tension upon the suture lines. In general, I support Burton,[11] who, with a vast experience in the repair of inguinal hernias, has reported that he has used the McVay procedure in approximately 10 per cent of all hernias operated upon.

Of equal, if not greater, importance than the choice of ligaments is the care with which the inguinal region is explored and the surgical technique used in performing the herniorrhaphy. A careful search must be carried out to be

certain that all loculations of the sac are discovered. McClure and Fallis[33] found that, in a series of 90 femoral hernias, 22.3 per cent of the patients had previously undergone repair of an inguinal hernia on the same side. Such a high incidence of femoral locules in recurrent inguinal hernias suggest the possibility that these accessory sacs were overlooked at the time of the original repair. The danger is greater in the case of an indirect sac being overlooked during the repair of a direct hernia. I feel that Hoguet's[21] maneuver should be carried out in all hernia repairs so that the redundant peritoneum is removed and so that all loculations are accounted for.

TABLE IV. THE CRITERIA WHICH SHOULD BE PRESENT BEFORE CONSIDERING REPAIR OF THE ILIOPECTINEAL (COOPER'S) LIGAMENT*

All femoral loculations of the sac Inadequacy of the inguinal ligament	absolute indications
Arborization of the sac Generalized laxity of the inguinal wall Widening interligamentous space Refractory hernias	equivocal indications

*Taken from Burton: Evolution and Classification of Hernial Operations, Internat. Abstr. Surg., Surg., Gynec. & Obst. 87: 325, 1948. (By permission of Surgery, Gynecology and Obstetrics.)

A careful closure of the transversalis fascia, the use of aponeurotic rather than muscular portions of the layers of the abdominal wall, the use of a fastidious surgical technique to prevent wound complications, and particularly the absence of tension on suture lines, are still factors of prime importance in the prevention of recurrences following a hernia repair.

SUMMARY

The historical development of the surgical treatment of inguinal hernia has been traced from the pre-Homeric era to the present.

Attention is called to the fact that a significant number of recurrent hernias are due to a technical defect in the performance of the original operation, irrespective of the type of herniorrhaphy performed.

If the fundamental principles of hernia surgery are violated the patient will not be protected from a recurrence by the selection of any specific procedure.

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In Memoriam

René Leriche
1879-1955

RENÉ LERICHE was born Oct. 12, 1879, in Roanne, Department of the Loire, son of a barrister, grandson and nephew of surgeons, and with three physicians in the families of his grandparents. He graduated in medicine from Lyon in 1905, was first demonstrator in anatomy, and then became assistant to Poncet (a pioneer surgeon of his period), and also made the acquaintance of Alexis Carrel. In 1910 he became associate professor, and began his teaching career in earnest. His insatiable thirst for knowledge soon led him to travel widely in order to observe at first hand the works of the masters of the day. He visited Krönlein and Kocher in Switzerland, and Czerny and Trendelenberg in Germany. When still relatively young, in 1910, he first visited the United States where he was profoundly influenced by Halsted at Hopkins. After this he repeatedly stated that Halsted was one of those who kept alive the true spirit of Claude Bernard. He also became acquainted with Harvey Cushing and in 1929 was invited to serve as Surgeon-in-Chief Pro tempore at the Peter Bent Brigham Hospital and later received a similar honor on invitation from Cutler at Western Reserve University in Cleveland.

He was called to head Surgical Clinic A in the University of Strasbourg in 1924, a post he held until 1939. This was perhaps his most fruitful epoch. His service was literally a mecca for surgeons young and old from all parts of the world, including many Americans. In 1937 he was appointed to the Chair of Experimental Medicine in the College de France, one of the highest honors accorded a French physician and a fitting tribute to his genius as he was the first surgeon awarded this post.

He retired a few years ago, living in Paris, but also frequently residing on his pastoral estate at Cassis in southern France where he loved to be out of doors in the sunlight among flowers and fruit trees in full view of the Mediterranean Sea and hills of the shore line.

His work was very comprehensive and embraced many fields. A summary would require too much space for review here. His first contribution of note in 1913 was periaterial sympathectomy, which procedure is often referred to as Leriche's operation. He noted the initial segmentary contractions of larger arteries when their adventition was stripped away and the subsequent distal vasodilatation. This work was greatly extended to a consideration of the surgery of the sympathetic nerves in general. Later contributions included the

The many American friends and admirers of René Leriche were greatly saddened at the news of his sudden death on the 28th of December, 1955. While at work at his desk, he suddenly collapsed and expired within a few moments.—A. Brunschwig.

syndrome of obliteration of the aorta at its bifurcation (Leriche's syndrome) and segmental arterial resections in general. Attention was called to the obliterated arterial segment as the site of afferent impulses producing noxious reflexes (angina, etc.). These contributions afforded much of the basis for the physiological background of modern arterial and sympathetic nerve surgery. The relationship of the sympathetic nerves to endocrine disturbances, hypertension, parathyroid dysfunctions, and so forth were also subjects for many publications.

Since his active military service in World War I he became greatly interested in trauma especially to the central and peripheral nervous systems. He was one of the first to point out that amputation neuromas could be the source of noxious reflexes affecting muscles, blood vessels, bones in the operated extremity, and even the higher nervous centers.

In 1934, he coined the very appropriate term, "maladie postoperatoire" for that very complex situation affecting practically all functions in a patient recovering from a surgical procedure.

The physiology and surgery of the osseous system was also a subject for special consideration. With Policard he was the author of a classic and very provocative monograph on ossification, supporting the thesis that this was essentially a humeral phenomenon. The part played by the sympathetic nervous system and ligaments in the pathology and pathologic physiology of the skeletal system was constantly emphasized. The effects of pain, causing immobilization, edema and hyperemia in the subsequent course of fractures, sprains, and so forth, could not be overemphasized according to Leriche. The suppression of these factors aids in recovery from the initial disturbance and failure to alleviate them may result in irreversible changes (osteoporosis). The salutary effects of local infiltration by novocain were first demonstrated by him in the treatment of sprains and fractures as well as other peripheral neuromuscular disturbances.

A fundamental concept of Leriche was that functional disturbances might precede visible lesions.

Leriche spent the whole day in his clinic; Sundays and other holidays were no exception. He interrupted his routine only to go abroad to further his own observations and in acquiescence to invitations to lecture, consult, and operate. He was a most humane and understanding person. He stated that "one should learn to waste time with patients." He realized the great therapeutic effect of permitting patients to pour out their troubles to their doctors, problems even unrelated to their specific complaints. He admonished those about him to constantly view every disease with "new eyes," and to be impressed with everything. He was never satisfied with classical and current explanations for disease, but constantly sought different ones more appropriate to newer concepts.

Leriche had an immense respect for the human personality and dignity. In the course of over twelve years' personal contact while working with him, I never witnessed an instance of his becoming ruffled; he was always complete master of his emotions and temperament. He never exhibited impatience by gesture or word and was solicitous of all his patients including the most humble, the curable and incurable alike.

He leaves behind him a considerable literary heritage; in 15 books and several hundred articles he bequeaths his observations, experience, and modality of thought.

Many of his pupils both in France and abroad have become professors. He was the recipient of numerous honorary degrees, prizes, and society memberships including Honorary Fellowship in the American College of Surgeons and American Surgical Association. Recently his last great award was from the Argentinian Confederation of the Liberal Professions, a sort of Nobel Prize in Medicine designated to reward the person who has contributed most to the advancement of humanity. He was its first recipient and his work, "The Surgery of Pain" figured prominently among the reasons for the award.

He was buried in all simplicity on the last day of 1955 at Lyon, France in the presence of his wife, his faithful collaborator of many years, his daughter, his family, and his pupils. An official funeral was refused as were flowers and discourses.

As he had worked among his colleagues, but being one of the great of his epoch, he departed, in all simplicity and without emphasis. The highest spiritual values, creative genius, the greatest qualities of heart were all united in this man.

—ADOLPHE JUNG
Professor and Director of the Surgical Clinic
Faculty of Medicine, University of the Sarre,
Homburg

Calendar of Surgical Meetings

THE AMERICAN ACADEMY OF NEUROLOGICAL SURGERY. *Annual Meeting,* Nov. 1-3, 1956, Camel Back Inn, Phoenix, Ariz. Secretary, Eben Alexander, Jr., M.D., Bowman Gray School of Medicine, Winston-Salem, N. C.

AMERICAN ASSOCIATION FOR THE SURGERY OF TRAUMA. *Annual Meeting,* Oct. 4-6, 1956, The Biltmore, Santa Barbara, Calif. Deadline for papers, July 1, 1956. Secretary, James K. Stack, M.D., 700 N. Michigan Ave., Chicago 11, Ill.

AMERICAN COLLEGE OF SURGEONS. *Clinical Congress,* Oct. 8-12, Civic Auditorium, San Francisco, Calif. Secretary of the College, Michael L. Mason, M.D., 154 E. Erie St., Chicago 11, Ill.

AMERICAN MEDICAL ASSOCIATION. *Annual Meeting,* June 11-15, 1956, headquarters, Navy Pier, Chicago, Ill. *Clinical Session,* Nov. 27-30, 1956, Civic Auditorium, Seattle, Wash. Deadline for papers, Aug. 1, 1956. Secretary, Council on Scientific Assembly, A. M. A., 535 N. Dearborn St., Chicago 10, Ill.

THE AMERICAN ORTHOPAEDIC ASSOCIATION. *Annual Meeting,* June 16-20, 1956, Banff Springs Hotel, Banff, Alberta. Secretary, George O. Eaton, M.D., 4 East Madison Ave., Baltimore, Md.

LATIN AMERICAN CHAPTER OF INTERNATIONAL SOCIETY OF ANGIOLOGY. *Third Meeting,* Nov. 8-11, 1956, Havana, Cuba. President, Armando Núñez Núñez, Calle 25 No. 510, Vedado, Havana, Cuba.

NEW ENGLAND SURGICAL SOCIETY. *Annual Meeting,* Oct. 5 and 6, 1956, Poland Springs House, Poland Springs, Maine. Deadline for papers, June 1, 1956. Secretary, Richard Warren, M.D., Peter Bent Brigham Hospital, 721 Huntington Avenue, Boston 15, Mass.

SOUTHERN SURGICAL ASSOCIATION. *Annual Meeting,* Dec. 4-6, 1956, the Boca Raton Club and Hotel, Boca Raton, Fla. Deadline for papers, Sept. 20, 1956. Secretary, George G. Finney, M.D., 2947 St. Paul St., Baltimore, Md.

Book Reviews

The Spine. By Bernard S. Epstein. Pp. 539. Philadelphia, 1955, Lea & Febiger.

This book fills a long-felt need for a monograph on the spine in the English language. The roentgenographic features of the normal spine are presented by a series of photographs of the spine and roentgenographs of the spine in the same projection. This material provides a base line for all of the deviations from the normal considered in successive chapters. It is a tribute to the author that he has been able to cover a vast amount of material without redundancy. The descriptions of the individual conditions are concise and documented with the important references to the literature. The x-ray reproductions are numerous and of excellent quality. This book should be in the library of every radiologist and orthopedist. It will also be of great value to pediatricians and internists as well as general practitioners. The author and the publishers have produced a valuable as well as an attractive reference work.

A Manual of Fractures and Dislocations. By Barbara Bartlett Stimson. Pp. 224. Philadelphia, 1956, Lea & Febiger.

This small book on fractures and dislocations is designed for students, interns, and general practitioners. In a very simple and straightforward fashion the conservative management of the common fractures and dislocations is presented. The line drawings illustrating the text add tremendously to the value of the book. Space has been conserved by careful organization of the material so that each fracture is discussed in terms of occurrence, displacement, diagnosis, pathology, treatment, the length of immobilization, the prognosis, and the complications which occur. At the end of each section is a short summary. This book can be highly recommended for use by the group for whom it is intended.

Arthroplasty. By St. J. D. Buxton. Pp. 126. Philadelphia and Montreal, J. B. Lippincott Company.

This little book of only 126 pages contains a historical review of the subject of arthroplasty as well as a résumé of the author's experience and views on the subject. It is very interesting to see that major contributions to the development of arthroplasty have been made by American surgeons, particularly John Rhea Barton of Philadelphia who performed the first arthroplasty of the hip, Dr. J. B. Murphy of Chicago who gave a tremendous impetus to this type of surgery and to Smith Petersen of Boston who spent his life perfecting methods for arthroplasty of the hip. The general principles involved in arthroplasties are fully discussed and the indications and contraindications for this type of surgery are noted. There is considerable attention devoted to the use of replacement prostheses in arthroplasties of the hip. This book should be of interest to any surgeon who is engaged in reconstructive surgery.

Postural Back Pain. By Milton C. Cobey. Pp. 78. Springfield, Ill., Charles C Thomas, Publisher.

This small monograph is concerned with the relationship of poor posture to back pain. The author stresses the fact that the development of poor postural habits during

childhood and adolescence can contribute to a variety of syndromes of back pain appearing during adult life. Good postural habits can reduce morbidity due to back pain. This monograph illuminates one facet of the complex problem of back pain.

Surgery of the Small and Large Intestines. By Charles W. Mayo, Section of Surgery, Mayo Clinic, Rochester, Minn., Professor of Surgery, Mayo Foundation Graduate School, University of Minnesota. Pp. 340. Chicago, 1955, The Yearbook Publishers, Inc. $9.00.

This is the sixth in a series of handbooks of operative surgery. Dr. Mayo presents in a lucid fashion a summarization of the techniques he employs in surgery of the small and large intestines, with special attention being devoted to the surgery of the large bowel. The various operative techniques are presented pictorially by means of diagrammatic line drawings with a brief description accompanying each of these techniques. The author presents these as the best procedures culled from his many years of clinical practice.

In addition, Dr. Mayo describes various dietary regimens used in the preoperative and postoperative stages plus other aspects employed in the routine preoperative preparation and postoperative care of patients undergoing these operations.

The book is to be recommended to those desiring a brief summarization of the surgical techniques that may be employed in this region. It is not to be recommended to anyone requiring a detailed description of these techniques.

Airborne Contagion and Air Hygiene. By William Firth Wells. Pp. 423. Cambridge, 1955, Harvard University Press.

For about twenty-five years, Professor Wells and his associates have been studying the problem of airborne infection. Many of their concepts which seemed quite unorthodox when first promulgated have since been substantiated. Others are highly controversial and, in fact, have been rejected by investigators who have also worked in this field. In the former category are Wells's laboratory findings as to dissemination, survival, and destruction of airborne pathogens; in the latter are some of the inferences and conclusions as to the significance and success of various attempts to control the spread of infection through air sterilization.

This volume brings together in one place the results of Wells's highly valuable studies. Many of the details of the original articles are obviously omitted or condensed. An attempt is made to formulate various postulates and general principles and to reduce these so far as possible to mathematical expression.

This is not light bedtime reading. Rather, it is a scholarly work that must be read carefully line by line and word by word with appropriate allocation of time to think over and absorb complex ideas. It is a book for the serious student of this problem, not for the casual reader.

The engineer will find much with which he will agree, for the author, himself an engineer, approaches the problems of dissemination of organisms on a sound physical basis of laboratory experimentation. The epidemiologist, on the other hand, will of necessity take many exceptions to some of the author's conclusions and deductions as to the effectiveness of air disinfection in prevention of spread of infection among individuals who move freely within the community and are thus breathing disinfected air at one moment and nondisinfected air at another. There will be an inevitable feeling that the author has been too arbitrary in his assumptions as to where certain infections were contracted. The critic will also wonder at the omission or underemphasis of certain studies that showed a failure to control airborne infection through air disinfection. The scholarly character of the book would have been increased if there had been more dispassionate appraisal of conflicting data and less strenuous advocacy of one point of view. It would also have been improved if, in a highly controversial situation, the author had not felt that "elaborate statistical studies (were not) needed" since the favorable results "were obvious to an ecologist watching the shuttles of infection."

Thromboembolic Disease. By Geza DeTakats, M.D. Pp. 48. Springfield, Ill., 1955, Charles C Thomas, Publisher. $2.25.

This short monograph gives an excellent review of thromboembolic disease. The author's concept of therapy is well outlined and one that should meet with general acceptance. The advantages and disadvantages of the use of heparin and the coumerol derivatives are well discussed. A concept of a stress phenomenon as manifested by the clotting mechanism is presented which incorporates a situation of depletion of natural heparin stores.

It is felt that this monograph would be of value for any physician as well as those especially interested in the field of vascular disease. It is easy to read, broad in concept, and specific in its outline of therapy.

The Year Book of General Surgery (1955-1956 Year Book Series). Ed. by Evarts A. Graham, with a Section on Anesthesia edited by Stuart C. Cullen. Pp. 655, with 181 illustrations. Chicago, 1955, The Year Book Publishers, Inc.

The Year Book under the editorial supervision of Dr. Evarts A. Graham, Emeritus Professor of Surgery at Washington University School of Medicine in St. Louis, continues to be an important source book to all students of general surgery. There appears to be as much, if not more, editorial comment upon the various abstracted articles as in earlier years when Dr. Graham was active in the operating theater.

In his introduction to the volume, Dr. Graham alludes to the profound changes which have occurred in surgery during the past decade making possible extension of many operative attacks upon disease. Nevertheless, Editor Graham voices some sympathy for the articles abstracted in the volume which protest against some of the current radical procedures for cancer.

The volume continues the high standard set by its editor in earlier years.

Blood Supply and Anatomy of Upper Abdominal Organs with a Descriptive Atlas. By Nicholas A. Michels, M.A., D.Sc. (Louvain), Professor of Anatomy at the Daniel Baugh Institute of Anatomy, Jefferson Medical College. Pp. 581, with 172 illustrations including 166 in color. Philadelphia, 1955, J. B. Lippincott Company.

The author, well-known Professor of Anatomy at Jefferson Medical College in Philadelphia, has succeeded in producing a book which will be of tremendous interest to surgeons of the upper abdomen. The author has dissected 200 bodies with a view of characterizing the normal as well as the abnormal distribution of vessels to organs in the upper abdomen. He has employed three artists to present his findings in a graphic and lucid manner. The larger number of illustrations are in color, a circumstance which makes the illustrations particularly interesting.

In the preface the author says that he has devoted twenty years to the accumulation of the data which have made this atlas possible. Moreover, the author has made a careful study and digest of the literature, which in many instances traces back to the origin of anatomic dissections.

Surgeons, and anatomists too, should find this book informative and very readable.

Suprapubic Prostatectomy With Primary Closure of the Bladder by an Original Method: Preparation, Technique and Postoperative Treatment. By Univ.-Prof. Dr. Theodor Hryntschak, translated by Noble S. R. Maluf, M.D. Pp. 187. Springfield, Ill., 1955, Charles C Thomas, Publisher. $8.50.

Professor Hryntschak was director of the urologic division of the Municipal Polyclinic of Vienna; his translator is chief of urology at the Veterans Hospital in Houston. They became acquainted during the war. The original text, published in German in 1951, was a plea for Hryntschak's method of suprapubic enucleation of the prostate. It

is unfortunate that the book has been translated too literally, because this makes reading a little difficult; one is distracted by the Germanic constructions. However, the book is short enough so that this is unimportant. It will repay reading by anyone who is interested in prostatic operations.

The reviewer would like to admonish the translator for relegating a photograph of the author to a lower corner of a page in the introduction, while using six cystograms of his own (the translator's) patients as a frontispiece; the publisher has concealed the table of contents behind 30 pages of introductory material. The latter are composed of 24 pages by Dr. Maluf, and of three more introductions by the author, his former assistant, and by the widow of the author. A review of the translator's own 35 cases precedes Professor Hryntschak's text.

The contents include discussions of the history of suprapubic prostatectomy, of primary suture of the bladder, and of the examination of the patient, his preparation for operation, and of disadvantages of the inlying catheter. Peridural anesthesia is considered at some length. There follows a detailed, step-by-step description of the operation. Through a median incision, the anterior wall of the previously distended bladder is widely exposed above the space of Retzius, and is perforated with a hemostat through a tract made by the pointed aspirator used to evacuate the vesical contents. The author emphasizes the importance of spreading this perforation bluntly with a hemostat instead of incising it, because he feels that a separation of the detrusor fibers is more likely than an incision to remain watertight after closure.

A blind, bimanual suprapubic enucleation is then done, after which the wall of the bladder is spread with the author's retractor to expose the prostatic fossa. Catgut sutures are then placed through the vesical aspect of the edge of the prostatic fossa so as to grasp as much as possible of the surgical capsule of the gland as they emerge into the fossa. When tied, they afford considerable hemostasis. A catheter is inserted, and the portion of the fossa anterior to the catheter is then obliterated with one to three transverse catgut sutures. These enter the vesical aspect of the edge of the fossa and emerge as close to the apex of the latter as possible, then enter the fossa at a corresponding spot on the opposite side, and emerge in the bladder. The opening of the anterior wall of the bladder is then closed with a purse string of catgut which, according to the author, must not perforate the mucosa if leakage is to be prevented. This is supplemented with a Z suture or a second purse string, and the abdominal wall is closed around half of a small rubber tube which has been split lengthwise. Complications occurring during operation are discussed.

There follows a detailed description of postoperative care with particular emphasis on those precautions necessitated by the primary closure of the bladder. The catheter is removed as early as the second postoperative day if bleeding has stopped; the number of patients requiring reinsertion appears to be remarkably small. Postoperative complications are discussed adequately.

There is a lengthy statistical summary of the author's first 100 personal cases, and of 200 more performed by him and by his associates. There were 12 deaths in the 300 cases (4 per cent), including one from sepsis, four each from pulmonary embolism (which he calls the arch fiend of prostatectomy) and from cardiac disease, two from uremia, and one from paralytic ileus. Figures are not so presented as to permit determination of the average postoperative stay in the hospital, but 180 of the first 250 patients stayed more than 10 days. In 235 of 280 patients the catheter was removed by the end of the fifth postoperative day; only three suprapubic fistulas required closure.

Thrombosis and embolism are discussed in considerable detail, and a few examples are presented of primary closure of the bladder after operations other than prostatectomy (papillomas, stones, etc.).

A mortality of 4 per cent for prostatectomy in Vienna during and immediately after the war represents a remarkable achievement when one considers the probable nutritional status of patients, as well as the shortage of antibiotics which must have prevailed during the earlier part of the series. Consequently it is hardly fair to point out

that the mortality of well-done transurethral resection is only about one per cent; however, it tends to confirm my suspicion that transurethral resection is inherently safer than an open operation on the prostate.

This book is worth reading because it is full of valuable technical details.

New Concepts in Surgery of the Vascular System. By Emile Holman, M.D. Ed. by Michael E. DeBakey and Art Glenspurling. Pp. 108. Springfield, Ill., Charles C Thomas, Publisher.

This monograph consists of two lectures given by Dr. Holman. The first on "The Immediate and Late Treatment of Arterial Injuries" was presented as the David W. Yandell Lecture before the Louisville Surgical Society and the second "The Pathological Physiology of Post-Stenotic Dilatation. Its Significance in the Development of Arterial Aneurysms" was presented as the Arthur Dean Beven Lecture before the Chicago Surgical Society.

In the first section the great improvements in the treatment of arterial injuries that have been achieved, especially since the beginning of the Korean war, are described. The most important advance has been the substitution of repair and reconstruction of the injured artery for the older treatment of ligation. The various factors that have made this change in treatment possible are described. The Z-plasty type of arterial anastomosis which the author has advocated previously is discussed as a method for joining arteries without reducing the lumen. The place of this and other methods of anastomosis in the treatment of arteriovenous fistulas is described.

In the second section which concerns the phenomena of poststenotic dilatation in the arterial system, the author describes his important research and clinical observations. The author has been able to reproduce the phenomena of poststenotic dilatation in inanimate laboratory arrangements where a pulsating liquid is pumped past a constriction into a rubber tube. The physical factors that ultimately produce a dilatation in this experiment as well as in clinical examples of poststenotic dilatation are discussed. The author also suggests that most arteriosclerotic aneurysms are actually poststenotic dilatations distal to arteriosclerotic narrowings. Of the various mechanisms and theories that are presented, perhaps the least convincing is that of the part that "structural fatigue" may play. This is probably due to the fact that "structural fatigue" is not carefully defined in the text.

The monograph should be of interest to the many surgeons now concerned with the problems of vascular surgery.

Praktische Anatomie. By T. von Lanz and W. Wachsmuth. Pp. 549. Berlin, Springer-Verlag.

This volume on the neck represents Part 2 of Volume I of the long and ambitious program of surgico-anatomical books contemplated by these authors. Just prior to World War II, the two volumes appeared covering the upper and the lower extremities. The work of Lanz in Anatomy is well known. He is Director of the Anatomical Institute at the University of Munich. Wachsmuth is Director of the Surgical Clinic at Wurzburg.

Like its predecessors, this Volume II is magnificent. There are 321 illustrations, many of which are in color. Most of the dissections employed by surgeons are well illustrated, together with nice anatomic detail. The volume can be recommended without reservation as constituting one of the finest books of its kind that has been done upon the importance of the anatomy of the neck for the surgeon. The illustrations are beautifully done and are appealing and restful to the eye. Even the surgeon who does not read German well will enjoy the illustrations.

Intracranial Gliomata. By John Penman and Marion C. Smith. Pp. 70. London, 1954, Her Majesty's Stationery Office.

This 70-page report contains data on a series of 298 consecutive cases of intracranial gliomas. Included are statistics on the frequency according to age, sex, and location of tumor, on symptoms and signs, on radiological aspects, and on therapy. The report is essentially a statistical study made from the clinical records. The authors, it seems, had little or no personal experience with the patients. The frailty of the report is that most all the statistics revolve around the pathologic type of tumor but no basis is given for the authors' interpretation of the characteristic histology for these specific types. Also conclusions on surgical therapy are given but only a paragraph is detailed to the description of the therapy. For example, reference is made to "partial" and "complete" removal of tumors and to "extensive surgery" without defining these terms relative to area of cerebrum involved. Is extensive surgery applied to a tumor located in the frontal region the same as extensive surgery applied to one located in the parietal area? The value of the report lies in its addition to the literature of a sizeable series of cases from a well-recognized neurosurgical clinic. The material is presented concisely, the charts are lucid. It is a monograph that is of value to anyone interested in brain tumors.

Segmental Anatomy of the Lungs. A Study of the Patterns of the Segmental Bronchi and Related Pulmonary Vessels. By Edward A. Boyden, Ph.D. (Med. Sc.). Pp. 276, with 125 illustrations and 11 color plates. New York, 1955, McGraw-Hill Book Company, Inc.

This monograph by Professor Edward A. Boyden is the fruit and culmination of ten years of industrious and continued injury into the nature of the hilar and intrapulmonary anatomy of blood vessels and bronchi. As Dr. Evarts A. Graham says in the foreword: "Everyone with an interest in this subject may congratulate himself that an anatomist of the caliber of Edward Boyden has devoted his energies to the production of this classic work."

Dr. Boyden reviews the early history of the anatomy of the lungs with reference to blood vessels and bronchi commencing with the work of Malpighi in 1661, tracing each development made by contributions from anatomists, surgeons and roentgenologists.

Dr. Boyden first presents the materials in a general survey of the pulmonary tree, including a discussion of prevailing patterns and terminology. He then discusses each lobe of the lung individually, indicating the bronchial distributions, and the prevailing patterns of segmental arteries and veins. There is a final chapter on the development of the lungs and the formation of gross congenital anomalies.

The book is well written; the materials are interestingly presented. A vast amount of information concerning the minute details of the gross anatomical features of the bronchi and blood vessels of the lungs is annotated in this study. The book is printed on excellent paper, and the illustrations, a large number of which are in color, are unusually good. The last segment of the book presents a series of 11 color plates illustrating the hilar and lobar distribution of the bronchi and the blood vessels. There is a bibliography of approximately 120 references, the majority of which are fairly recent literature.

For long years this volume will undoubtedly serve as the chief guide for anatomists, radiologists, and surgeons who wish to consult a reliable source on the segmental anatomy of the lungs. It can be recommended as an important and useful reference.

Der Magen und seine Krankheiten.. Ed. by Professor Reinhold Boller with the collaboration of a large number of European authors. Pp. 854, with 243 illustrations and 8 plates. Vienna, 1954, Urban & Schwarzenberg, 115 DM.

The editor of the monograph, Dr. Reinhold Boller, is well known for his interest in gastroenterology. He has previously authored two texts on the stomach. In the present

volume, he has only written the section on the Postoperative Stomach. Physiologists, pathologists, internists, radiologists, and surgeons have joined their efforts to make this an authoritative text. The section on History of Diseases of the Stomach is written by Leopold Schönbauer, Professor of Surgery at the First Surgical Clinic, University of Vienna. The section on the Anatomy of the Stomach is written by Professor Eduard Pernkopf of the Anatomical Institute in Vienna. Professor Torsten Teorell, recent Nobel Prize winner, wrote the section on Physiology of the Stomach. Professor Georg Konjetzny wrote the section on Pathological Anatomy. The late Professor Hans Finsterer wrote the section on Surgical Management of Gastric Disorders. Sir Avery Jones of Middlesex Hospital, London, wrote the section on Geography, Climate, and Social Factors relating to diseases of the stomach. This brief review affords some suggestion of the comprehensiveness of coverage of the subject matter in this text.

The subject of diseases of the stomach is considered under the following chapter headings. (1) Theoretical Considerations, (2) Diagnosis, (3) Symptomatology and Manifestations, (4) Therapy, (5) Diseases of the Stomach Under Varying Physiological Environmental Conditions, (6) The Significance of Gastric Diseases in Various Oral Systems, (7) The Relationship Between Systemic Diseases and the Stomach, and (8) Prophylaxis. Each chapter has a reasonably comprehensive bibliography, most of which understandably is of European origin.

Every serious student of the stomach will want to peruse this interesting monograph. It contains a wealth of information and is authoritatively written. It will undoubtedly find a large number of interested readers.

Bickham-Callander Surgery of the Alimentary Tract. By Richard T. Shackleford, assisted by Hammon J. Dugan. 3 volumes. Pp. 2575, with an additional 139 pages of index and 1,705 illustrations. Philadelphia, 1955, W. B. Saunders Company. $60.00.

In 1924 the late Dr. W. S. Bickham of New York completed a six-volume presentation of the techniques of general and special surgery, describing and illustrating the conventional techniques of operative surgery. Following Bickham's death, the late Dr. C. L. Callander of California undertook preparation of a second revision. Dr. Callander was engaged upon the project for almost ten years up until his death in 1947. In 1949, Dr. Shackleford, Assistant Professor of Surgery at Johns Hopkins University School of Medicine, undertook the problem of completing a two-volume work on surgery of the alimentary tract. In an interesting preface, Shackleford states that he had envisaged completion of the task within a year. However, that labor lengthened to a three-volume work, entailing six years in preparation. That Dr. Shackleford and Dr. Dugan have spent a great deal of time and effort upon this task is immediately apparent to anyone who takes the pains to peruse these volumes.

The authors have included the alimentary tract and its abdominal appendages in their treatise. It is a mature and thoughtful work. The illustrations are good. Many of these are reproduced from other authors. Some are redrawn. The references to current literature are many and have been well selected. There is little to criticize and much to praise in these volumes.

All abdominal surgeons will find these volumes a helpful and useful source of reference. The authors have done their work well and the treatise can be enthusiastically recommended to the profession.

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